



Georgia Institute of Technology
1974-75 General Catalog

Tentative Calendar 1974-75

An official institute calendar is prepared and distributed each quarter by the Office of the Registrar. Dates, filing times, deadlines and other information included in the official calendar supersede previously published information such as that included in this catalog. Students are responsible for adhering to the requirements set by the official calendar.

Summer Quarter 1974

June 20	Registration.
July 4	Holiday.
Aug. 31	End of term.

Fall Quarter 1974

Sept. 16	Registration.
Nov. 5	Classes dismissed — State-wide elections.
Nov. 28	Begin Thanksgiving recess.
Dec. 1	Last day of Thanksgiving recess.
Dec. 7	End of term.
Dec. 8	Begin Christmas recess.
Jan. 5	Last day of Christmas recess.

Winter Quarter 1975

Jan. 6	Registration.
Mar. 19	End of term.
Mar. 20	Begin spring recess.
Mar. 30	Last day of spring recess.

Spring Quarter 1975

Mar. 31	Registration.
June 11	End of term.

Summer Quarter 1975

June 19	Registration.
Aug. 30	End of term.

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1/ General Information



General Information

The Georgia Institute of Technology, founded in 1885, is a co-educational institution of higher learning located in Atlanta, Georgia.

In 1888 the school opened its doors to the first class of future mechanical engineers. At that time the campus consisted of five acres of land and a physical plant of two buildings. One of these original buildings is still in daily use as part of today's 128-building physical plant which sprawls over 280 acres of land.

Tech's enrollment has paralleled the growth of the physical plant. The original class numbered only 129 students, all but one from Georgia. This year over 8,000 students from every state and from over 60 foreign countries are expected to pursue undergraduate or graduate degrees in the 20 engineering, architectural, scientific and management schools and colleges that make up Georgia Tech.

Nationally prominent in education and research, Georgia Tech is also famous for its colorful traditions — the Ramblin' Wreck parade and the school song of the same name, football and hard-working students who approach play with zest and ingenuity. Georgia Tech alumni support, from graduates scattered throughout the world, is consistently among the strongest in the nation.

Academic Offerings

Georgia Tech offers programs of study leading to twenty-seven undergraduate and twenty-eight graduate degrees. General information about these programs is contained in the "Information for Undergraduate Students" and the "Information for Graduate Students" sections of this book. More specific information can be found in the "Curricula and Degrees" section.

Academic Calendar

Georgia Tech operates on the quarter plan with the fall, winter and spring quarters normally constituting the academic year. A full summer quarter is also offered, and many students accelerate their program by attending four quarters per year. A program of study may be entered in any one of the four quarters. The requirements for a degree may be completed at the end of any quarter, and a commencement ceremony is held at the end of each quarter.

See page ii for the academic calendar for 1974-75.

Special Supporting Facilities

Computer Facilities

The Office of Computing Services provides a wide range of computing services in instruction, research and administration. The center operates a Univac 1108 in the shared processor system configuration with batch, demand and remote time-sharing facilities. A Calcomp Digital Plotter system and an analog-to-digital conversion system are also available. An IBM 360/30 computer is used for administrative support. Georgia Tech is a leading institution in a National Science Foundation sponsored experiment to implement a regional computer network.

The School of Information and Computer Sciences also operates a Burroughs B-5500, a multiprogramming and multiprocessing system with remote time sharing capabilities, two PDP computer systems and an information processing laboratory.

The Applied Computer Research Division conducts computer-related research.

Department of Continuing Education

This department annually conducts up to 200 educational programs designed to help professionals in technology keep pace with their field, advance in their profession or retrain for a related field. The short-term courses are intensive in subject coverage. Special technical and management short courses, as well as conferences and institutes, train key industry personnel by providing information and instruction on new developments and best methods. The department cooperates closely with industry, trade associations and professional organizations in planning and presenting these special educational programs.

Engineering Experiment Station

The Engineering Experiment Station, activated in 1934, operates a number of specialized facilities of importance to industrial and academic research. These include chemical and physical analytical laboratories, two electron microscopes, a central machine shop and a photographic and reproduction laboratory. The research and development laboratories include some of the South's most advanced technological facilities in areas that include the biological, chemical, nuclear and physical sciences, electronics and microwave engineering, high temperatures and materials, mechanical design and development and waste product utilization. The industrial extension service, which works

with business and industry to further the economic and technological growth of Georgia, maintains offices in Albany, Augusta, Carrollton, Douglas, Macon, Rome and Savannah. Graduate students may be appointed as graduate research assistants in the Engineering Experiment Station, and may participate in investigations that could provide the topic for a thesis.

Health Systems Research Center

The Health Systems Research Center offers an interdisciplinary and interinstitutional program of health systems research, education and service which applies the disciplines of industrial and systems engineering, economics, behavioral science, operations research and management science. HSRC promotes active collaboration with academic institutions, medical organizations, health planning and government agencies and health-care institutions in Georgia and throughout the nation.

Research programs develop systems for planning, designing and managing health care facilities, manpower and methods and techniques for evaluating current and proposed health-care delivery systems. The center also provides educational seminars and courses, and provides data sources for health systems research. Courses and curricula of the program in health systems, administered by HSRC through the College of Engineering, are described in the "Curricula and Degree" section.

Interdisciplinary Programs

The Office of Interdisciplinary Programs, established in October 1973, is a focus for interdisciplinary study at Georgia Tech. There are currently two units, the Bioengineering Center and the Environmental Resources Center, within the Office of Interdisciplinary Programs. Neither center offers designated degrees, but members of the faculty teach courses in other departments and schools of the institute, conduct various research endeavors, engage in public service activities and coordinate appropriate interdisciplinary activities.

Bioengineering Center. The Bioengineering Center's emphasis is in the application of the knowledge, techniques and approaches of the physical sciences, engineering, social sciences and management to the problems and research needs of the biological sciences in attaining the quality of life. In addition to developing relevant interdisciplinary study and research opportunities for qualified students at Georgia Tech, the center conducts cooperative programs in bioengineering education and

research with other units of the university system and with the Emory University School of Medicine.

Environmental Resources Center. The Environmental Resources Center coordinates applications of Tech's expertise in science and technology and other socio-economic inputs in addressing problems of managing such environmental resources as water, land and air. The center teaches courses in resource management, assists in the development of interdisciplinary curricula, administers a federal traineeship program and organizes and administers water resources research projects and disseminates their results throughout Georgia.

Library

The Price Gilbert Memorial Library's scientific, engineering and management collection includes 750,000 volumes, 600,000 microtexts and 175,000 other bibliographic units. The library will accommodate one million volumes and seat 2,000 users.

The library has a collection of over one million patents, the largest in the Southeast. In 1962 it was designated one of twelve Federal Scientific Report Centers, and its collection of such documents from governmental agencies now totals 500,000 titles. The library is a depository for governmental publications issued by the U.S. Government Printing Office and for maps issued by the U.S. Defense Mapping Agency, Topographic and Aerospace Centers, U.S. Geological Survey and the U.S. National Ocean Survey. The government documents collection contains 225,000 publications and 100,000 maps.

Over 9,300 serials, including 5,000 periodicals, are currently received, approximately 75 percent of them in scientific and technical fields. Especially strong is the collection of abstracts, indices and bibliographies for science and engineering.

Microfiche copies of the entire card catalog are available on every floor in the library and in each academic department on campus. The Georgia Tech library is associated with eight other libraries in the Atlanta area and in Athens, Georgia and offers a union catalog of the holdings of all member libraries. The library is also affiliated with the University of Georgia's Information Dissemination Center, which provides computer-based searches of published literature.

Nuclear Research Center

The Frank H. Neely Nuclear Research Center provides Georgia Tech with outstanding research capability in fields of interest to nuclear engineering. Included are a heavy-water-moderated, five-

megawatt research reactor, a low-power training reactor, a sub-critical assembly, PDP-8 data acquisition system, hot cells for handling highly radioactive materials remotely, a 12,000-curie cesium-137 radiation source and a one-million-volt Van de Graaff accelerator.

Oak Ridge Associated Universities

Georgia Tech is a member of the ORAU. Through this cooperative association, the school has at its disposal the facilities of the National Laboratories at Oak Ridge. When a master's or doctoral candidate has completed his resident work at Georgia Tech, it is possible for him to go to Oak Ridge to do his research problem and to prepare his thesis.

Skidaway Institute of Oceanography

Located on Skidaway Island near Savannah, the Skidaway Institute provides a complex of coastal- and marine-related educational and research opportunities. Members of the Tech faculty and their students can arrange to participate in ongoing research or initiate research consistent with the facility's purpose.

Southern Technical Institute

Southern Technical Institute is a unit of the College of Engineering that is designed to meet the needs of the student who wishes to become an engineering technician, an engineering technologist or a fire science technician. Eleven two-year and seven four-year technology programs are offered on the campus in Marietta, Georgia. Accreditation has been given by the Engineers' Council for Professional Development, the national engineering technology accrediting agency, to the two-year curricula leading to associate degrees in the following engineering technology fields: apparel, architectural, civil (options in structural materials and design and in surveying and construction), electrical (options in electronics and in computers and control), industrial (including industrial management option), mechanical and textile, as well as to the four-year curricula leading to bachelor's degrees in the following fields of engineering technology: apparel, architectural, civil, electrical, industrial, mechanical and textile. These curricula are designed to provide the basic scientific training, the specialized technical know-how, and the supervisory and management training needed by the engineering technician and engineering technologist. The courses are briefer, more intensive and more specific in purpose than those of the professional engineering

curricula, although they lie in the same fields of industry and engineering. Their aim is to prepare the individual for specific technical positions or lines of activity, rather than for broad sectors of engineering practice. A catalog is available upon request.

Student Life

The dean of students and his staff are responsible for coordinating and administering out-of-classroom student services and activities. Complete information concerning all student activities, organizations and general student information is contained in the *Student Handbook*, available to all students on campus.

Community Services. Through community service, Georgia Tech applies its resources to the needs of the community and provides outlets for creative individual response to social problems.

Counseling Center. A Counseling Center assists students with almost any difficulty. Professional counselors assist in a completely confidential manner with academic, career and personal difficulties whenever requested. Additional services include career information, catalogs from other colleges, information for admission to law, business and graduate schools, and a wide variety of interest, ability and personality tests.

Fraternities and Sororities. The Fraternity Affairs Office coordinates and administers the many activities and programs of the 31 social fraternities and sororities on the Tech campus.

Housing Office. The Housing Office supervises 3,550 single spaces and 300 married student apartments. A residence hall program provides counselor services, programs and activities for the dormitory residents.

Infirmary. The modern 70-bed infirmary is fully staffed with medical doctors, registered nurses and medical and psychological consultants. All students are provided this service for a \$15 quarterly fee. Major medical insurance is optional at a nominal fee.

International Students. International students services and programs help students from other countries adjust to Georgia Tech and to American customs and culture. Many of the 400 students from 60 foreign countries assist in providing programs to promote intracultural understanding and adjustment.

Orientation. The new student orientation program familiarizes the new undergraduate student with the activities and academic

programs at Georgia Tech as well as the traditions, services and opportunities on campus.

Placement. The Georgia Institute of Technology operates a centralized placement operation serving all degree candidates for career employment. The principal services available to students and employers are campus interviews, a weekly bulletin listing position vacancies and communication information for more than 3,000 prospective employers. In addition, the Fred W. Ajax Placement Center staff conducts orientation and employment seminars to aid students in their employment search. Summer and part-time position openings are also made known to the students through the placement center. Formal campus interview periods are October and November and January through April, but interviews can be arranged at any time with at least two weeks notice.

Student Center. The Fred B. Wenn Student Center is the campus "living room." The staff and facilities of this center plan and coordinate constant programs and activities for students, faculty, alumni and their guests.

Student Government. Tech's student government provides the means for self-government in all areas of the institution's student-related activities. Through the student council and the graduate senate the student body maintains responsible and respected participation in both academic and non-academic areas which affect the student in some manner.

Student Publications and Radio. The student publications and radio communications boards oversee the budgeting and operation of the official student newspaper, yearbook and other publications, and the operation of the student F.M. radio station.

Women's Programs. Women students services and programs are directed toward involving female students in all phases of campus life and providing resources to fulfill the institute's intention of accepting as many qualified female students as apply.

Affiliated Organizations

The Georgia Tech Athletic Association

This nonprofit corporation administers intercollegiate sports at Georgia Tech. The board of directors consists of seven faculty members, three alumni and three students. The president of Tech is chairman of the board. The board aims to secure cooperation of the faculty and students in athletic affairs to maintain a high standard of sportsmanship and to create adequate facilities for every student to take part in some athletic activity. Intercollegiate

schedules are played in football, basketball, cross country, swimming, track, golf, tennis, baseball, gymnastics and wrestling.

The Georgia Tech National Alumni Association

The Alumni Association is a nonprofit corporation dedicated to serving Georgia Tech. Some of its objectives are to maintain an up-to-date record of each alumnus, publish *Tech Topics*, organize and service local alumni clubs, operate a free placement service for alumni, organize special alumni events, furnish a medium through which alumni may aid the president and faculty, aid visiting alumni, help publicize the achievements of Georgia Tech and raise funds for Tech through the annual alumni roll call. The alumni secretary acts as a central contact for all alumni.

The Georgia Tech Foundation, Inc.

This non-profit corporation solicits and administers funds for Georgia Tech and its students. The foundation is directed by a board of outstanding alumni business leaders who administer the funds received to the best of their judgment for the improvement of the school. The funds are presently used to supplement the compensation of faculty members in order to obtain or retain outstanding faculty members, to undertake special programs which cannot be financed by state funds for the development of Georgia Tech and to enable faculty members to improve their professional qualifications and standing by grants for such purposes as advanced degrees.

The Georgia Tech Research Institute

This non-profit corporation administers and seeks funds for research activity at Georgia Tech both in the academic colleges and in the Engineering Experiment Station. It is the coordinating agency for patent applications and other matters related to the protection and use of technological discoveries made at Georgia Tech.

Accreditation

The Georgia Institute of Technology is an accredited member of the Southern Association of Colleges and Schools. Accreditation has been given by the Engineers' Council for Professional Development, the national engineering accrediting agency, to the four-year engineering curricula leading to bachelor's degrees in

the following fields: aerospace engineering, ceramic engineering, chemical engineering, civil engineering, electrical engineering, engineering science and mechanics, industrial engineering, mechanical engineering and textile engineering as well as to the graduate programs leading to master's degrees in the following fields: aerospace engineering, ceramic engineering, civil engineering, electrical engineering, industrial engineering, mechanical engineering, metallurgy, sanitary engineering and textile engineering. The curriculum leading to the degree Master of Architecture is accredited by the National Architecture Accrediting Board. The curriculum leading to the B.S. in chemistry is accredited by the American Chemical Society. The College of Industrial Management is accredited by the American Assembly of Collegiate Schools of Business.

2/ Information for Undergraduate Students



TECH

Degrees

The Georgia Institute of Technology at present offers curricula leading to the following undergraduate degrees.

Bachelor of Aerospace Engineering
Bachelor of Architecture
Bachelor of Ceramic Engineering
Bachelor of Chemical Engineering
Bachelor of Civil Engineering
Bachelor of Electrical Engineering
Bachelor of Engineering Economic Systems
Bachelor of Engineering Science
Bachelor of Industrial Engineering
Bachelor of Mechanical Engineering
Bachelor of Nuclear Engineering
Bachelor of Textile Engineering
Bachelor of Science
Bachelor of Science in Applied Biology
Bachelor of Science in Applied Mathematics
Bachelor of Science in Applied Physics
Bachelor of Science in Applied Psychology
Bachelor of Science in Building Construction
Bachelor of Science in Chemistry
Bachelor of Science in Economics
Bachelor of Science in Information and Computer Science
Bachelor of Science in Industrial Design
Bachelor of Science in Industrial Management
Bachelor of Science in Management Science
Bachelor of Science in Physics
Bachelor of Science in Textile Chemistry
Bachelor of Science in Textiles

To graduates who have completed their courses under the co-operative plan, the degree is awarded with the designation "Cooperative Plan."

Special Programs

The Cooperative Plan

Since 1912 Tech has offered two plans of study in engineering: the standard four-year plan and a five-year cooperative plan for students who wish to combine practical experience with technical theory.

Approximately 1,000 students enrolled in the cooperative program are employed in over 240 industries throughout the eastern half of the country.

The cooperative division offers programs for majors in aerospace, chemical, civil, electrical, industrial and systems, mechanical and textile engineering, including textiles and textile chemistry, and in chemistry, engineering science, physics and industrial management. The academic curricula are identical to those offered regular four-year students.

The plan operates on alternating college and industrial quarters. The students are divided into two sections, the first registering in June and the second in September. The co-ops of section one and those of section two alternate between industry and college, exchanging places with each other every three months for four years. At the beginning of the fifth year the two sections merge and remain at college together until graduation in June, when each cooperative student receives a bachelor's degree, cooperative plan, in his particular field.

Students in the cooperative division are selected from applicants on the basis of high scholarship and physical fitness.

Practical experience, the primary purpose of the plan, is a valuable asset to young graduates starting out in their chosen profession. Neither college laboratory experience nor practical working experience during summer vacations can take the place of organized co-op training in industry. The plan provides, to a substantial degree, the experience most companies require their engineers to have before promoting them to positions of responsibility.

In addition to the value of practical experience to the students in seeking employment after graduation, they may learn early in their college careers whether they wish to continue the study of engineering as a life profession.

The second purpose, understanding the human element in engineering, is another important consideration of engineering corporations. While working in industry, students come in daily contact with both college and non-college men among their fellow employees. Through working with such diverse groups, students get a practical insight into sociology, ethics, economics and psychology that never could be gleaned from textbooks.

A third and significant purpose is financial. Firms that employ cooperative students compensate them for service rendered. Although students are not able to earn all of their college expenses, as a rule they can earn more than half.

Students interested in applying for admission to the cooperative plan should write to Director, Cooperative Division, Georgia Tech, for the division's bulletin which gives such information as fees, living expenses and wages paid students while at work.

Dual Degree Program

Many high school students are seeking a broadly based educational experience involving the types of college programs generally found at a liberal arts college as well as professional education in technology. Georgia Tech has developed an extensive network of college contacts through the Dual Degree Program to serve their needs. Under this plan the student attends a liberal arts college for approximately three years, then comes to Tech for two years. Upon completion of the program he receives a bachelor's degree from the liberal arts college and a professionally oriented master's or bachelor's degree from Georgia Tech.

Programs of study at Tech may be centered in any of the various specialty areas of engineering, science, mathematics or management, as well as in the engineering technology degree program at Southern Technical Institute. The colleges participating in the Dual Degree Program include most of the units of the University System of Georgia, the Atlanta University Center Colleges and 55 other colleges and universities throughout the nation. The list of participating colleges is increasing rapidly and includes seven traditionally black colleges as well as more than ten predominately women's colleges.

ROTC

Georgia Tech has three entirely voluntary ROTC programs: Army, Navy and Aerospace Studies. The Air Force and Navy programs train both men and women.

Six hours of basic ROTC and nine hours of advanced ROTC may be used as elective credit toward a degree. Students who earn a baccalaureate or higher degree and successfully complete the advanced ROTC courses of any of the three services are selected for commissioning in either the reserve or the regular forces.

Each ROTC unit offers scholarship programs of two, three and four years. All juniors and seniors selected for the advanced courses receive a substantial monetary allowance each month while enrolled in ROTC.

Preprofessional Programs

Pre-medical, pre-dental and pre-law programs are offered at Georgia Tech. None of these are specified as degree programs as such, but if a student takes the proper courses from the various curricula, these objectives can certainly be met.

To obtain a pre-law background, a bachelor's degree in almost

any engineering or management area or a degree in psychology would be most acceptable. The institute has a pre-law adviser in the College of Industrial Management. Students are encouraged to consult with him regarding their plans for meeting law school entrance requirements.

The student considering a career in medicine or dentistry may meet the minimum subject requirements for entrance to medical or dental school under the degree programs in the sciences or engineering.

Quite often students declare a major in biology for a pre-medical background since the courses taken routinely in the biology curriculum include all the subjects listed in the *Medical School Admissions Requirements, USA and Canada*.

Another highly recommended major for pre-medical or pre-dental students is health systems engineering. This curriculum forms an excellent background and it provides the systems orientation now being favored by leading medical educators. By selecting the appropriate elective courses, the entrance requirements of most medical and dental schools can be completed within the framework of the health systems engineering curriculum. This major has the added advantage of keeping a college student's options open throughout the undergraduate level for possible future employment in any number of challenging and rewarding careers in the entire health-care field, rather than serve solely as a pre-medical or pre-dental major.

Pre-medical and pre-dental requirements can be met in other science and engineering majors at Georgia Tech. Again, by using carefully chosen electives, one can major in chemistry, chemical engineering, electrical engineering, industrial and systems engineering, mechanical engineering, physics or psychology. With the flexibility now available in electives, it is also possible to major in other areas of engineering.

Each pre-med and pre-dental student is advised to consult early in his college career with the institute's pre-medical advisory committee for information about general and specific requirements.

Joint Enrollment Program for High Schoolers

Georgia Tech admits a limited number of gifted students who have finished the eleventh grade and who have academic credentials that would place them in the upper part of Tech's freshman class.

A student admitted in this category will normally take all his coursework at Tech. The courses taken will include those subject areas the student needs to fulfill his high school requirements for

graduation. High school credit is given for such courses, and the student actually graduates with his high school class. All work taken at Georgia Tech is also applicable toward an institute degree if it is a part of a particular curriculum undertaken by the student at a later date.

To be eligible to participate in this program, the local school system must have signed the appropriate agreement with the Georgia Institute of Technology. Students should check with local school officials to determine if their particular system is a participating member. If so, the student should check with the high school counselor regarding specific course, test and recommendation requirements for JEPHS. If further information or assistance is required, contact the Director of Admissions at Georgia Tech.

Advanced Placement and Honors

See page 21.

Special Studies

Georgia Tech is dedicated to helping each student realize his or her full academic potential. For this purpose a variety of programs present different approaches to aid in overcoming academic stumbling blocks. Each of the programs is based on voluntary participation by students needing the services available. These include the following.

A mathematics laboratory where any Georgia Tech student needing help with a freshman level mathematics course may obtain tutoring. The laboratory is operated by the mathematics department from 1 to 5 p.m. Monday through Friday during weeks when classes are in session.

A laboratory course conducted by the English department in the mechanics of reading is designed for students who desire to increase their reading speed and improve their comprehension of written material.

English and literature for international students are courses designed for students whose native language is not English. They are intended to introduce international students to written and spoken English as well as American social situations, customs, ideas and literature.

English for students who fail the regents' examination is a special course taught for students who desire further preparation before retaking it.

STEP is a service located in the Bridge Room of Brittain Dining Hall where students may obtain help with any freshman level

course. This help is in the form of quick answers to telephoned questions on current assignments, short personal tutoring sessions and occasional group coaching in particularly troublesome areas. STEP is coordinated through the office of the dean of engineering.

Admissions

Admission Requirements

While there is no set deadline for filing applications for freshman admission to the fall quarter, it is advisable for candidates to make application not earlier than one year or later than six months prior to the date of the beginning of the quarter for which applying. Transfer students must have all required credentials on file in the Office of Admissions within twenty days of the date of the beginning of the quarter for which applying.

Georgia Tech reserves the right to refuse to accept an application at any time when it appears that students already accepted will fill the institute to its maximum capacity. The institute also reserves the right to reject an applicant who is not a resident of the State of Georgia.

The single most important criterion of any decision of acceptance is the probability of the applicant completing the requirements for the desired degree. The institute reserves the right, in every case, to reject any applicant whose overall credentials do not indicate a probability of success, notwithstanding the satisfaction of other requirements. Applicants must comply with such procedures, including personal interviews and psychological or other tests, as may be necessary to determine the applicant's general fitness for admission. If an interview is required, the director of admissions will notify the applicant of the time and place at which the interview will be conducted.

The decision as to whether an applicant shall be accepted or rejected will be made by the director of admissions, subject to the applicant's right of appeal as provided by the bylaws of the institute and of the Board of Regents of the University System of Georgia.

Required High School Background

Students who are considering Georgia Tech should be sure to plan their high school schedules to include the following required courses.

Engineering-Science

English	4
Algebra	2
Plane Geometry	1
Advanced Algebra	$\frac{1}{2}$ ¹
Trigonometry	$\frac{1}{2}$
Chemistry	1
Lab Science	1
History	1

Architecture

English	4
Algebra	2
Geometry	1
Advanced Algebra	$\frac{1}{2}$ ¹
Trigonometry	$\frac{1}{2}$
Science	2
History	1

Industrial Management

English	4
Algebra	2
Geometry	1
Science	2
History	1

Language is not required for entry to Georgia Tech, but at least two years of a modern language is recommended. Extra courses in mathematics and science are recommended. A course in mechanical drawing and one in typing also prove useful if they can be conveniently scheduled. The total number of high school units completed should be sufficient to ensure graduation under local requirements. Students unable to schedule required courses should write to the director of admissions for information regarding ways of making up missing high school credits.

The institute reserves the right to reject the credits from any high school or other institution regardless of its accredited status, where the institute determines from investigation that the quality of instruction available at such high school or institution is for any reason deficient or unsatisfactory.

¹Title of course is not important. All students entering in engineering, science and architecture must have sufficient mathematical background for the first quarter introductory calculus.

College Board Test Requirements

All applicants for admission in engineering, science and mathematics are required to take the Scholastic Aptitude Test. College Board Achievement Tests are not required. Students who wish to be considered for placement in advanced courses in English, mathematics, chemistry, modern languages or social science should schedule and make available the appropriate achievement tests results.

Admission Decision

The following items must be on file before any admission decision can be rendered.

Application for Admission. It is recommended that the completed application be given to the high school and mailed to the admissions office with the transcript. Cooperative student applicants must file an additional application for cooperative courses. No application fee is required.

High School Transcript. It must cover the first three years of high school with student's senior year schedule indicated by semesters. A school may use its own standard transcript form rather than the form provided. The high school's form is acceptable if it shows the applicant's rank in class, grading system, accredited status of the school and any honors or advanced courses completed.

Scholastic Aptitude Test Results. Applicants should make certain that a copy of the scores be sent to Georgia Tech from Princeton, New Jersey. Reproductions of scores received by the high school are also acceptable.

Admission Notification

The Office of Admissions operates on a rolling admission plan, that is, after the application for admission, school transcript and SAT scores have been received, evaluation and action on an application will be possible. Applications are not reviewed in any special order, such as by school or alphabetically, so it is most likely that friends or classmates will receive admission action letters at different times.

Applicants who indicate a preference for the cooperative plan on the application for admission will be mailed an application for cooperative courses. This must be received before consideration for admission can be given. Cooperative plan applicants will not be processed as rapidly as standard applications.

Applications for financial assistance awarded by Georgia Tech can be obtained by writing to the Office of Student Financial Aid and the required college scholarship service forms can be obtained from the high school. Financial aid awards are made between March and May.

NROTC scholarship notifications will be sent as soon as Georgia Tech receives the certified list of candidates from the Department of the Navy. This usually occurs in April.

Failure to file any of the above material or failure to respond promptly to requests for further information will delay the processing of an application.

Early Notification of High School Seniors. A high school student who is well qualified and interested in attending Georgia Tech may receive early notification of acceptance.

In the summer before the senior year, an application for admission, transcript of credits (including senior schedule by semesters), SAT scores and a written request for early consideration should be submitted. Upon receipt of all information required, a candidate will be notified as soon as possible of the decision, whether affirmative or negative.

Early notification in no way binds the student to Georgia Tech as he is not normally obligated to a single application. Applicants refused early notification will automatically be considered later under regular admission without any penalty or further application.

Early Admission of High School Juniors

See page 15.

Admission of Transfer Students

The applicant should consult the leaflet of special information for transfer students for application procedures and test requirements. It is necessary for all applicants to be in good academic standing at the previous college. Courses completed in other colleges must have an overall average of C or better, and grades must be satisfactory for the term immediately prior to transferring. All required credentials must be filed within twenty days of the date of the beginning of the quarter for which applying.

Admission of Women

By action of the board of regents on December 13, 1967, qualified women students were ruled eligible for admission in all programs

of study offered at Georgia Tech. The requirements for admission and the regulations governing students apply alike to men and women, except that women students will not be required to fulfill the same physical education requirements as men.

Admission of International Students

A special information pamphlet for foreign students is available upon request which indicates the application procedures for both freshmen and undergraduate transfers and other basic information helpful to applicants from other countries.

Advanced Placement and Honors Program

Superior students entering Georgia Tech may receive college credit for courses completed in high school if their scores on the college board advanced placement program examinations indicate a satisfactory knowledge of college course work. Advanced placement and credit are offered by the schools of chemistry, mathematics and physics and departments of English, modern languages and social sciences. Advanced sectioning is possible in chemistry on the basis of high scores on the college board achievement tests. A number of students in the engineering college whose scores on the SAT-verbal and the English achievement test examinations are sufficiently high are given the option of waiving one or more of the freshman courses as prerequisites to enrollment in the upper-level courses offered by the English department. An honors program is offered in mathematics. Participation in advanced placement, advanced sectioning and honors programs is voluntary.

Veterans Program

As early as possible, and preferably at least one month before entering Georgia Tech, any student planning to enroll under any of the Veterans Administration programs should visit the financial aid office on the Georgia Tech campus to initiate enrollment certification procedures. The veteran should bring with him such items as proof of discharge (DD-214), marriage license and birth certificates of dependent children which are required to define an individual's eligibility. Eligible veterans will be certified in advance of enrollment in order to expedite the first benefit check. Students who request enrollment certification on the day of registration should anticipate a four to six week delay in the receipt of the first benefit check. All questions regarding procedures for certification should be directed to the Office of Financial Aid located on the

ground floor or the Administration Building on the Georgia Tech campus.

The veteran planning to further his education under veterans' benefits at the Georgia Institute of Technology should apply for admission as any other student. Eligibility for Veterans Administration benefits has no direct relationship to the institution. All financial transactions are directly between the student and the Veterans Administration. The institution serves only as a source of certification and information to the Veterans Administration.

Most veterans who served on active duty for more than 180 days, any part of which occurred after January 31, 1955, are generally eligible for financial support to attend college.

Generally sons and daughters between 18 and 26 years old of deceased veterans, those of living veterans who have disabilities which are considered to be total and permanent, and those of veterans whose death or disability was a result of service in the armed forces are eligible for financial benefits to attend college. Contact your local Veterans Administration office for complete details.

The local Atlanta Veterans Administration address is: 730 Peachtree Street, N.E., Atlanta, Georgia 30308.

Health Information

Health Information Record forms are mailed to students with the notice of their acceptance for enrollment. These forms are to be completed by the prospective student and mailed to the director of health in sufficient time to be received prior to the date of initial registration. After review of the report, the school physicians determine the assignments to ROTC and physical training.

Any student who desires special consideration because of mental or physical disability should have his physician write an explanatory letter to the director of health giving full details of the disability and any desired limitations on physical activity. This letter is to be attached to the health information record. Any special examinations or reports needed to determine eligibility for enrollment or assignment are at the expense of the student, not the school. Any student who fails to submit the required immunization record prior to registration will have the necessary immunization ordered by the school at the expense of the student.

Readmissions

Georgia Tech students who find it necessary to discontinue enrollment for one or more quarters, with the exception of a summer quarter, must apply for readmission when planning to

return to the institute. An application for readmission may be obtained from the Office of the Registrar, and must be completed and returned at least 20 calendar days prior to the beginning of the quarter to which readmission is sought. Additional information is available in chapter six, section VI-F of this catalog.

Academic Regulations

Detailed information regarding the academic regulations of the institute is contained in chapter six of this catalog, "Rules and Regulations." Questions concerning academic regulations should be directed to the general office of the student's major school or to the Office of the Registrar, Room 104, Administration Building.

Grading System

Detailed information regarding the grading system is contained in chapter six of this catalog, "Rules and Regulations," section IV.

Examination and Grade Reports

Final examinations are scheduled during the last week of each quarter and reports of the student's academic progress are issued after the close of the quarter.

Scholastic Average

The scholastic average of an undergraduate student includes the grades of all courses scheduled after being admitted to the institute. Grades received on previous courses are not replaced by higher or lower grades received at some later date. All course grades are averaged in just as any new course scheduled. The graduate average includes the grades on all courses scheduled by the student after being admitted to the graduate division, plus the grades on all courses listed on the student's approved program of study which have been earned at Georgia Tech prior to his admission to the graduate division. The scholastic average is computed by dividing the total number of quality points earned by the total number of credit hours scheduled.

Transfer Credit

The basic policy regarding the acceptance of courses by transfer is to allow credit for courses completed with satisfactory grades (C or better) in other accredited colleges provided the courses

correspond in time and content to courses offered at the Georgia Institute of Technology. In no case will credit be allowed (except by examination) for courses completed at another institution that have previously been failed at Georgia Tech. An official transcript received directly from the previous institution must be provided the Office of the Registrar by the student before the credit can be awarded.

Auditors

Any officially enrolled student who has obtained the approval of his adviser and the departments of instruction concerned may audit courses. No credit is granted for courses scheduled on an auditing basis, however, and students are not permitted to change to or from an auditing status except through the regular procedures for schedule changes and during the period for changes as published in the college calendar for each given quarter. All students registered as auditors are required to pay tuition at the regular rate. Members of the faculty or staff of the Georgia Institute of Technology may sit in on a course providing permission is obtained from the department concerned and the registrar.

Constitution and History Examinations

The Georgia law as amended March 4, 1953 requires that before graduation all students pass examinations or pass comparable courses in United States and Georgia history as well as United States and Georgia Constitution. Courses which may be substituted for the United States and Georgia Constitution requirement are Pol. 1251 or Pol. 3200. Courses which may be substituted for the United States and Georgia history examinations are Hist. 1001, Hist. 1002, Hist. 3010 or Hist. 3011.

Regents' Testing Program

All students are required by the University System of Georgia to demonstrate proficiency in reading and English composition by passing an examination by the end of the sophomore year.

ROTC Credit

Six quarter hours in basic ROTC courses and nine quarter hours in advanced ROTC courses are the maximum credits allowed toward meeting the requirements for any degree. See chapter six, section XVI.

Physical Education Credit

All degrees require three 1000-level courses of physical education including P.E. 1010. Individual schools must allow a minimum of three hours of physical education and may allow as many as six hours of physical education to be counted toward degree requirements. Students should check with their individual schools in order to determine the number of hours of physical education that may be counted toward their respective degrees.

Students who are exempted for physical reasons from all or any of P.E. 1010-20-50 will be required to take P.E. 1040. Students who are exempt because of age, military service or a transfer from another institution do not have to take P.E. 1040 and the hours required for physical education do not have to be made up with electives. Women students must satisfactorily complete any three hours of physical education in order to complete their physical education requirements. See chapter six, section XV.

Humanities and Social Sciences Requirements

A tabulation of the work required for degrees in the curricula offered by the Georgia Institute of Technology is given in chapter four of this catalog.

At least 36 credit hours of humanities and social sciences must be included in all curricula leading to an undergraduate degree.

College of Engineering. All students enrolled in curricula of the College of Engineering must take at least 36 hours of humanities and social sciences distributed as follows.

At least 18 hours of humanities (including at least three hours of literature) selected from the following subjects.

English: 1001, 1002, 1003, 1033, 2001, 2002, 2003, 2004, 2007, 2031, 2032, 2033, 2037, 2038, 2039, 3006, 3008, 3037, 3038, 3039, 3041, 3042, 3043, 3044, 3051, 3052, 3058, 3059, 3061, 3062, 3081, 3082, 3083, 4041, 4042, 4043, 4044, 4081, 4082, 4083.

Modern Languages:*

German: 3001, 3002, 3003, 3011, 3012, 3013, 3031, 3032, 3033, 3051, 4001, 4002, 4003, 4021, 4022, 4023, 4051, 4052, 4053, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

Russian: 3001, 3002, 3003, 4075, 4076, 4077, 4901, 4902, 4903, 4904.

Spanish: 3001, 3002, 3003, 4001, 4002, 4003, 4004, 4007,

*Up to nine hours of beginning modern language may be included, *provided that* nine additional hours of 2000-level or higher course work in the same language are also completed.

4008, 4009, 4010, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

French: 3001, 3002, 3003, 3011, 3012, 3013, 4001, 4002, 4003, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

Linguistics: 2001, 2002, 2003, 4001, 4002, 4003, 4901, 4902, 4903, 4904.

Music: 2001, 2003.

Architecture: 1201, 1202, 1203, 3201, 3202, 3203, 4201, 4202, 4203, 4241, 4242, 4243, 4244, 4245, 4246.

At least 18 hours of social sciences (including at least three hours of history and three hours of American government) selected from the following subjects.

History: 1001, 1002, 3001, 3003, 3004, 3010, 3011, 3012, 3013, 3017, 3018, 3020, 3022, 3024, 3025, 3028, 3030, 3040, 4025, 4050, 4075.

Philosophy and History of Science: 1126, 1127, 1128, 3100, 3102, 3103, 3104, 3105, 3107, 3115, 3116, 3117, 3118, 3119, 3120, 3121, 3122, 4106, 4107, 4108, 4110, 4115, 4116.

Political Science: 1251, 1253, 2270, 2271, 3200, 3203, 3204, 3205, 3210, 3216, 3217, 3220, 3221, 3222, 3265, 3266, 3270, 3275, 3276, 3280, 3281, 4200, 4201, 4202, 4210, 4211.

Sociology: 1376, 1377, 3306, 3310, 3330, 3334, 3335, 3338, 3339, 3340, 4306, 4308, 4312, 4750.

Modern Languages:

German: 2001, 2002, 2003, 3011, 3012, 3013, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

French: 2001, 2002, 2003, 3011, 3012, 3013, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

Russian: 2001, 2002, 2003, 4075, 4076, 4077, 4901, 4902, 4903, 4904.

Spanish: 2001, 2002, 2003, 3004, 3005, 3007, 3008, 3009, 4007, 4008, 4009, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

Linguistics: 2001, 2002, 2003, 4001, 4002, 4003, 4901, 4902, 4903, 4904.

Psychology: 3300, 3303, 3304, 4400, 4402, 4410, 4423, 4750.

Economics: 2000, 2001, 3000, 3001, 3002, 3400, 3500, 3501, 3502, 4300, 4332, 4340, 4341, 4400, 4420, 4500.

Socio-technology:

Civil Engineering: 4143.

Nuclear Engineering: 4620.

General College and Industrial Management College. All students enrolled in curricula of either the General College or the Industrial Management College must take at least 36 hours of humanities and social sciences distributed as follows.

At least 18 hours of humanities (including at least three hours of literature) selected from the following subjects.

English: 1001, 1002, 1003, 1033, 2001, 2002, 2003, 2004, 2007, 2010, 2031, 2032, 2033, 2037, 2038, 2039, 3006, 3008, 3037, 3038, 3039, 3041, 3042, 3043, 3044, 3051, 3052, 3056, 3058, 3059, 3061, 3062, 3076, 3081, 3082, 3083, 3084, 3085, 3086, 4041, 4042, 4043, 4044, 4051, 4081, 4082, 4083.

Modern Languages:

German: 1001, 1002, 1003, 3001, 3002, 3003, 3011, 3012, 3013, 3031, 3032, 3033, 3051, 4001, 4002, 4003, 4021, 4022, 4023, 4051, 4052, 4053, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

Russian: 1001, 1002, 1003, 3001, 3002, 3003, 4075, 4076, 4077, 4091, 4092, 4093, 4094.

Spanish: 1001, 1002, 1003, 3001, 3002, 3003, 3006, 4001, 4002, 4003, 4004, 4007, 4008, 4009, 4010, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

French: 1001, 1002, 1003, 3001, 3002, 3003, 3011, 3012, 3013, 4001, 4002, 4003, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

Linguistics: 2001, 2002, 2003, 3001, 3002, 3003, 4001, 4002, 4003, 4021, 4075, 4076, 4077, 4901, 4902, 4903, 4904.

Music: 2001, 2003.

Architecture: 1201, 1202, 1203, 3201, 3202, 3203, 4201, 4202, 4203, 4241, 4242, 4243, 4244, 4245, 4246.

At least 18 hours of social sciences (including at least three hours of history and three hours of American government) selected from the following subjects.

Social Science:

History: 1001, 1002, 3003, 3004, 3010, 3011, 3012, 3013, 3017, 3018, 3020, 3022, 3024, 3025, 3028, 3030, 3040, 4025, 4050, 4075.

Philosophy and History of Science: 1126, 1127, 1128, 3100, 3102, 3103, 3104, 3105, 3107, 3115, 3116, 3117, 3118, 3119, 3120, 3121, 3122, 4106, 4107, 4108, 4110, 4115, 4116.

Political Science: 1251, 1253, 2270, 2271, 3200, 3203, 3204, 3205, 3210, 3211, 3216, 3217, 3220, 3221, 3222, 3265, 3266, 3270, 3275, 3276, 3280, 3281, 4200, 4201, 4202, 4210, 4211.

Sociology: 1376, 1377, 3306, 3310, 3330, 3334, 3335, 3338, 3339, 3340, 4306, 4308, 4312, 4750.

Modern Languages:

German: 2001, 2002, 2003, 3011, 3012, 3013, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

French: 2001, 2002, 2003, 3011, 3012, 3013, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

Russian: 2001, 2002, 2003, 4075, 4076, 4077, 4901, 4902, 4903, 4904.

Spanish: 2001, 2002, 2003, 3004, 3005, 3007, 3008, 3009, 4007, 4008, 4075, 4076, 4077, 4091, 4092, 4093, 4901, 4902, 4903, 4904.

Linguistics: 2001, 2002, 2003, 3001, 3002, 3003, 4001, 4002, 4003, 4021, 4075, 4076, 4077, 4901, 4902, 4903, 4904.

Psychology: 3300, 3303, 3304, 4400, 4402, 4410, 4423, 4750.

Economics: 2000, 2001, 3000, 3001, 3002, 3400, 3500, 3501, 3502, 4300, 4340, 4400, 4420, 4500.

Financial Information

Costs

	Resident of Georgia	Nonresident of Georgia
Quarterly Fees		
Matriculation Fee	\$145	\$145
Nonresident Fee	0	295
Student Activity Fee	18	18
Health Service Fee	20	20
Total	\$183	\$478
Quarterly		
Books and Supplies	\$50	\$50
Room Rent	*\$107-117-142-162	*\$107-117-142-162
Board	\$235-275	\$235-275
Personal Expenses (clothing, laundry, recreation etc.)	\$150	\$150
Total Per Quarter	\$725-820	\$1020-1115
Total Per Year (3 quarters)	\$2165-2450	\$3050-3335
Total Per Year (2 quarters) for co-op students in school 2 quarters instead of 3	\$1445-1635	\$2035-2225
Additional Freshman Expenses slide rule, drawing supplies (in addition to quarterly costs)	\$100	\$100
Total per year freshmen only	\$2265-2550	\$3150-3435

*Dormitory Room Rent is normally: \$107-117 for freshmen, \$142 for sophomores and \$162 for seniors, graduate students and women.

Part-time students (those carrying less than 12 credit hours per quarter) who are legal residents of Georgia will be charged \$12 per credit hour. Non-residents will be charged \$37 per credit hour. All students scheduling six hours or more must pay the student activity and health service fees of \$38.

The above expenses do not include fraternity, club dues or transportation expenses. Since changes in fees may occur without notice, the student must refer to information provided on registration day by the Office of the Vice-president for Business and Finance for official amounts on fees and other institutional charges for each individual quarter. An extra fee may be charged in special courses. A deposit (in addition to the dormitory room deposit) is required of each accepted applicant for admission to the fall quarter as required in the letter of admission. Approximately two weeks following registration, this deposit will be refunded to the student by check mailed to his campus post office box. Any student who withdraws during the first quarter of his attendance shall have his admission deposit deducted before any computation is made of the refund to which he may be entitled.

Other Fees. Each person receiving a diploma must pay a diploma fee before graduating.

Examinations at other than regular examination times will be granted in exceptional cases only and by faculty action. Normally a fee will be charged in such cases.

A late registration fee of not more than \$16 is charged at the rate of \$10 for the first day after regular registration, and an additional \$2 for each of the next three days.

Refund of Fees. Refunds of matriculation, tuition or dormitory rents for reasons of withdrawal from the institute or dropping of subjects may be considered only upon written application to the business office for refund of fees. The application must be dated and signed by the individual requesting the refund.

A form is available from the registrar or the cashier's office to request the refund. A copy of the withdrawal application or drop slip must accompany the refund application. Student activity and medical fees are not refundable. Requests for dormitory rent refunds must be completed at the housing office by the individual.

Students who formally withdraw during one week following the scheduled registration date are entitled to a refund of 80% of the fees paid for that quarter.

Students who formally withdraw during the period between one and two weeks after the scheduled registration date are entitled to a refund of 60% of the fees paid that quarter.

Students who formally withdraw during the period between two and three weeks after the scheduled registration date are entitled to a refund of 40% of the fees paid for that quarter.

Students who formally withdraw during the period between three and four weeks after the scheduled registration date are entitled to a refund of 20% of the fees paid for the quarter.

Students who withdraw or drop a subject after a period of four weeks has elapsed from the scheduled registration date will not be entitled to a refund of any part of fees paid for that quarter. All requests for refunds must be received in the Office of the Vice-president for Business and Finance within one month following the registration date.

Undergraduate Financial Aid

Financial aid at the Georgia Institute of Technology is intended to assist as many students as possible to meet normal college expenses. No student should fail to consider attending Georgia Tech because of financial reasons. Georgia Tech will aid students either through school funds or by directing the student to other sources. The financial aid applicant should realize, however, that the amount of aid that can be granted seldom meets all educational expenses, and financial assistance will have to be supplemented by the student, family or other outside sources.

The Financial Aid Office has the responsibility of administering all funds provided to Georgia Tech for the assistance of undergraduate students. It also receives and assigns awards forwarded to the institution from outside agencies for the use of individual students.

All entering students, including transfer students, who wish to be considered for scholarships, grants, loans and/or work opportunities for any quarters of the academic year beginning in September should submit a Georgia Institute of Technology financial aid application prior to February 15. (The Parents' Confidential Statement should be submitted to the College Scholarship Service no later than February 1.) Financial aid awards to entering students are normally made prior to May 1.

Although the cooperative program at Georgia Tech is not a financial aid program, many of those who attend are able to assist themselves with their college expenses through this program. Approximately one-fifth of the undergraduate enrollment attends under the cooperative plan and earns from \$2,400 to \$3,400 per year. Co-op enrollment is restricted to students in the fields of engineering, science and industrial management. Since financial aid is not a prerequisite for consideration, a student attending under the cooperative plan will not be denied consideration for other aid because of his enrollment. Students desiring other information on the cooperative program should write to the director of the

Cooperative Division, Georgia Institute of Technology, Atlanta, Georgia 30332.

Many students obtain part-time employment at Tech or in the Atlanta area. Georgia Tech's placement center attempts to keep an up-to-date listing of opportunities, and most students will be able to help themselves through part-time employment if they so desire.

The primary purpose of financial aid at Georgia Tech is to provide assistance to students who, without such aid, would be unable to attend college.

The primary responsibility for financing an education rests with the student and his family. Any financial aid is, therefore, awarded according to individual need and individual college costs. Financial aid includes scholarships, grants, loans and employment, which may be offered to students singly or in combination.

The family of the applicant is expected to make a maximum effort to assist the student with college expenses. Financial assistance from colleges and other sources should be viewed only as supplementary to the efforts of the family.

The student also has a responsibility to contribute to his college expenses through such sources as savings, summer earnings and contributions from friends and relatives. Students receiving aid are expected to use part of their summer earnings to defray college costs.

Applications for financial aid may be obtained by calling or writing the Director of Financial Aid, Georgia Institute of Technology, Atlanta, Georgia 30332, (404) 894-4160. Requests for further information on any programs of aid should also be directed to the above address. A current *Undergraduate Financial Aid* bulletin, which lists all awards and all applicable procedures and regulations, will be sent upon request.

Medals and Prizes

The American Institute of Architects Medal and Certificate

The School Medal of the American Institute of Architects is given annually in Schools of Architecture accredited by the National Architectural Accrediting Boards, to a graduating student in recognition of scholastic achievement, character and promise of professional ability. The award is made possible through an endowment fund provided by the ex-

ecutors and heirs of the Henry Adams estate.

Each student so honored receives, in addition to the engraved silver medal, a certificate citing his accomplishment in architectural studies; the runner-up also may be awarded the certificate if the head of the school so requests.

The Alpha Rho Chi Medal

The Medal of Alpha Rho Chi, national professional architectural

fraternity, is given annually upon recommendation of the faculty of the School of Architecture, to that graduating student who has shown an ability for leadership, performed willing service for his school and gives promise of real professional merit through his attitude and personality.

The Honor Society of Phi Kappa Phi

Among the prizes offered for scholarship by the Georgia Institute of Technology is membership in the honor society, Phi Kappa Phi, to which a limited number of seniors representing all departments are elected annually. Phi Kappa Phi is a national organization with chapters in many of the leading universities and colleges.

The local chapter of Phi Kappa Phi awards annually a scholarship cup to that member of the senior class who, on the basis of all work taken in this institution, ranks scholastically as one of the first two students in the class.

Tau Beta Pi

Tau Beta Pi is a national honorary engineering fraternity with chapters in most of the leading engineering schools of the country. The Alpha Chapter of Georgia offers membership to approximately twenty-five engineering students of each graduating class who can qualify according to the standards of scholarship, character, loyalty, personality, leadership and school activities. The fact that Tau Beta Pi is the second oldest honorary fraternity in the country and numbers among its members many of our leading engineers makes membership in the society a coveted honor.

The local chapter of Tau Beta Pi awards annually a scholarship cup to an outstanding engineering senior who ranks among the first five of his class on the basis of all scholastic work taken in this institution.

Phi Eta Sigma

Phi Eta Sigma is a freshman honor society in which any male student is eligible for membership who has made an average of at least 3.5 on the work of the first term of the freshman year. The society awards a scholarship cup to the freshman who makes the highest average for the first term.

Chi Epsilon Award

The Chi Epsilon Award is given annually by the Georgia Tech chapter. The recipient is chosen from the five highest members, based on scholarship, of the senior class. The final choice of the recipient is made from the five candidates on the basis of leadership, sociability, practicality and scholarship. The winner receives a certificate and his name is placed on an honor roll in the Civil Engineering Building.

Textile Scholarship Medals

The Georgia Textile Manufacturers' Association awards a watch annually to a member of the senior textile class, based on scholarship throughout his course and for original effort in the work of the textile department during his senior year. The American Association of Textile Technologists makes an award annually in the form of a suitable plaque to a member of the graduating class of the School of Textile Engineering. The award is based on scholarship and other personal qualities which indicate an outstanding student.

Briaerean Scholarship Cup

The Briaerean Society of the Georgia Institute of Technology presents annually a scholarship cup to a senior member of the society whose scholastic average for a period of four and one-half years entitles the recipient to rank as one of the highest three members of the class.

Fraternity Scholarship Cup

The Interfraternity Council awards quarterly a scholastic cup to the chapter of that organization which makes the highest scholastic average.

Alpha Chi Sigma Prize

The professional chemical fraternity, Alpha Chi Sigma, annually presents a handbook to the junior who has made the best record in the chemistry or chemical engineering course.

Eta Kappa Nu

The Eta Kappa Nu Association, national electrical fraternity, awards annually an electrical engineering handbook to the regular sophomore electrical engineering student (on the basis of four quarters) or to the co-op pre-junior electrical engineering student (on the basis of four quarters) having the highest scholastic average.

Delta Kappa Phi

The Delta Kappa Phi Plaque is awarded annually to the graduating senior selected as the outstanding graduate in the textile department. A certificate is presented at the annual Honors Day exercises. Delta Kappa Phi is the oldest national honorary textile fraternity in the country.

Pi Tau Sigma

Pi Tau Sigma, national mechanical

engineering fraternity, elects to membership outstanding mechanical engineering students in the junior and senior years.

An annual award of an engineering handbook is made to the highest ranking sophomore student in mechanical engineering (based upon at least four quarters of work).

Aerospace Engineering Medal

The James Edward Oglethorpe Chapter of the Daughters of the American Colonists presents annually a medal to the member of the graduating class in aerospace engineering who has made the highest scholastic average, based on the work of at least four complete quarters.

Industrial Management Certificate

The Industrial Management Society, senior honorary organization for I.M. students, awards annually a certificate of scholarship to the senior in the College of Industrial Management who ranks first in his class on the basis of all scholastic work taken at Georgia Tech.

Gordon Gambill Memorial Endowment Award

An annual award of an appropriate book to the athlete with the highest academic grade each year at the sophomore, junior, or senior level from the following sports: baseball, basketball, football and track. This award is made in honor of the late Gordon Gambill, class of 1913.

The William Gilmer Perry Award

The Department of English awards annually a fifty-dollar bond to the student in his first year who has done the best work in freshman English. This award is made through the courtesy of the Georgia Tech Foundation, Inc., in

honor of Dr. William Gilmer Perry, late professor of English.

Alpha Pi Mu Award

The Alpha Pi Mu Award is presented yearly to extend recognition and honor to the senior student in industrial engineering who has exhibited outstanding scholastic achievement tempered with those individual characteristics which the members of Alpha Pi Mu consider necessary for success. The recipient of the award is chosen from the three top seniors scholastically, and the presentation is made at the annual Honors Day exercises.

The American Institute of Industrial Engineers, Atlanta Chapter Award

The American Institute of Industrial Engineers, Atlanta Chapter, award is presented to the industrial engineering junior who is most outstanding in scholastic attainment and who has demonstrated such personal qualities as leadership, character and breadth of interest. The presentation is made annually at the Honors Day exercises.

The American Institute of Industrial Engineers, Student Chapter Award

The American Institute of Industrial Engineers, Student Chapter, award is presented to the Industrial Engineering sophomore who is chosen from the top three in his individual engineering class as having the best combination of personal and academic qualities. This presentation is made annually at the Honors Day exercises.

Society for Advancement of Management Award

The SAM Award is presented at the annual Honors Day exercises

to the Industrial Management student who is the most outstanding in scholastic attainment and who has demonstrated such personal qualities as leadership, character and breadth of interest.

Georgia Engineering Society Awards

Four awards consisting of a cash prize and certificate are awarded each year by the Georgia Engineering Society. Three awards are given to juniors in the College of Engineering who have earned the highest accumulative grade-point average at the end of the winter quarter. Not more than one award is given to students in any one of the schools of engineering. One award is given to the junior in the School of Architecture who is judged by a committee to be the most promising all-around student. The recipients must have completed at least six quarters of work at the institute.

The American Society of Civil Engineers Award

The American Society of Civil Engineers Award is given annually by the Georgia Section of ASCE. The recipient is selected by a committee from a list of three candidates who have the highest point average among the graduating members of the student chapter of the ASCE and who have completed at least eight quarters of work at the institute. The award consists of the junior membership entrance fees and a cash prize of \$90.

Army ROTC Awards

The Georgia Tech Honor Award is awarded annually to the outstanding senior cadet.

The Superior Cadet Ribbon Award is awarded annually to the outstanding cadet in each year for

scholastic and military achievements.

The Beta Theta Pi Fraternity, Georgia Tech chapter, presents annually the McGuire Medal to the outstanding Distinguished Military Student of the Army ROTC.

The Georgia Society of Daughters of Colonial Wars presents annually a medal to the ROTC senior for excellence in Army ROTC leadership.

The Joseph Habersham chapter of DAR presents annually a medal to the ROTC senior who attains the highest rating in military science.

The Third Army Certificate of Meritorious Achievement is awarded annually to the ROTC senior on the basis of leadership development throughout his ROTC career.

The Armed Forces Communication Association presents an award annually to the outstanding senior Army ROTC cadet in the field of communications and electronics.

The American Legion Post No. 1 annually awards medals to an Army ROTC junior and senior for excellence in scholastic achievement.

The American Legion Fifth District Award is given annually to the junior and senior Army ROTC cadet for excellence in military achievement.

The Professor of Military Science Awards are presented annually to the ROTC junior and senior who are outstanding in the performance of daily military duties.

The Society of American Military Engineers presents annually a medal to the outstanding senior engineering student of the Engineer ROTC Branch.

A medal is given annually by the American Ordnance Association to the senior ordnance cadet who attains the highest rating in

leadership and ordnance scholarship.

The John S. Gage Memorial Award is awarded annually to a senior infantry cadet who displays distinguished leadership.

The Association of the U.S. Army ROTC Medal is awarded annually to the outstanding ROTC junior.

The Association of the U.S. Army presents annually a medal to the out-standing Infantry Branch junior.

The American Legion Medal is presented annually by the Fulton County Voiture 217, 40 and 8, Honor Society of the American Legion to the second year basic cadet who is accorded the highest rating in military subjects, personal qualifications, leadership and scholastic average.

The ANAK Society annually presents medals to the three freshmen who attain the highest ratings for proficiency in military science.

Awards are made annually to the three best drilled basic cadets.

Air Force ROTC Medals and Trophies

The Georgia Tech Honor Award is awarded annually to the outstanding senior cadet.

The Beta Theta Pi Fraternity, Georgia Tech Chapter, presents annually the McGuire Medal to the outstanding distinguished military student of the Air Force ROTC.

The ANAK Society of Georgia Tech annually awards a medal to an AFROTC cadet for outstanding contribution to esprit de corps.

The Scabbard and Blade Military Society gives annually an award for outstanding leadership in AFROTC corps training.

The local chapters of the Daughters of the American Revolu-

tion present annual awards to outstanding seniors in AFROTC.

American Legion Medals are annually awarded to both junior and senior AFROTC cadets for excellence in military achievement and scholastic achievement.

The Fulton County Voiture 217 La Societe des 40 Hommes et 8 Chevaux Medal is awarded annually to an out-standing senior in the flying category.

The Sons of American Revolution Award is presented annually to the outstanding freshman.

The Daughters of Founders and Patriots of America Award is presented annually to the outstanding sophomore.

The Old Guard Battalion of the Gate City Guard presents annually an award for excellence in AFROTC.

The Reserve Officers Association presents annual awards to outstanding cadets in AS 4000, AS 3000 and AS 2000.

The Armed Forces Communication and Electronics Association Award is presented annually to the outstanding AFROTC senior in the engineering field.

The Air Force Association annually gives a medal to the AFROTC senior who attains the highest rating for proficiency in leadership and scholarship.

The General Dynamics award is presented annually to the outstanding sophomore in the flying category.

The Air Force Times Award recognizes annually the senior showing most initiative in community relations.

The Military Order of the World Wars presents annual awards to recognize the most improved cadet in each aerospace studies class.

Naval ROTC Medals and Awards

The Georgia State Society, United States Daughters of War of 1812 awards a gold medal each year to the NROTC senior who achieves the highest rating in naval science.

The ANAK Society annually awards two medals: one to the NROTC junior showing highest proficiency in leadership, and one to the NROTC freshman showing highest proficiency in naval science.

The Scabbard and Blade Society gives an award annually to an outstanding NROTC senior.

The McGuire Medal, awarded by the Beta Theta Pi Fraternity, is presented annually to a distinguished senior.

The Atlanta Chapter of the Reserve Officers Association annually presents an award to an outstanding sophomore NROTC student.

An appropriate award is presented each year to selected NROTC members of the Georgia Tech Rifle Team for proficiency in rifle marksmanship.

The Society of American Military Engineers annually awards 10 engineering medals for the outstanding engineering NROTC seniors and 10 medals for the outstanding engineering NROTC juniors selected from all NROTC schools in the United States.

The United States Naval Institute presents awards annually to the senior scholarship NROTC student and the senior College Program NROTC student having the highest cruise aptitude marks for summer training.

The Marine Corps Association annually presents an award to an outstanding senior NROTC student who is a candidate for commission in the U.S. Marine Corps.

The Georgia Tech Honor Award

is awarded annually to the outstanding NROTC senior in scholarship, military achievement and leadership.

The Armed Forces Communication and Electronics Association presents a gold medal and certificate to the out-standing NROTC senior majoring in electrical, electronic or communications engineering.

The Fulton County Voiture 217 La Societe des 40 Hommes et 8 Chevaux presents a medal to the outstanding NROTC senior and junior for excellence in military achievement.

The American Legion Post No. 1 Award is presented to an outstanding NROTC sophomore in scholarship.

The American Legion Fifth District Awards are presented to an outstanding NROTC senior and junior for excellence in military achievement.

The Fulton-DeKalb Council of the Navy League of the United States presents a naval officer's sword to the senior NROTC student contributing most to the prestige of the NROTC unit.

The Old Guard Battalion of the Gate City Guard presents a naval officer's sword to the scholarship NROTC senior possessing most officer-like qualities.

The U.S. Marine Corps Reserve Officers Association presents a Marine Corps officer's sword to the outstanding Marine Corps option senior.

The Naval Reserve Association Award is an engraved watch presented each year to the NROTC senior showing outstanding proficiency in leadership.

The Professor of Naval Science Award is presented to the NROTC

junior with the highest scholastic average in navigation.

The North American Rockwell Award is awarded to the outstanding NROTC senior in the flight indoctrination program.

The General Dynamics Award is a plaque with scroll presented to an NROTC senior for outstanding achievement.

The Georgia Society of Professional Engineers Award

An award in recognition of demonstrated awareness of professional concepts in engineering is made annually by the Georgia Society of Professional Engineers.

The most outstanding engineering senior in the State of Georgia is chosen on the basis of interest in the professional aspects of engineering as evidenced by unquestioned personal integrity, participation in technical and professional activities and scholastic standing.

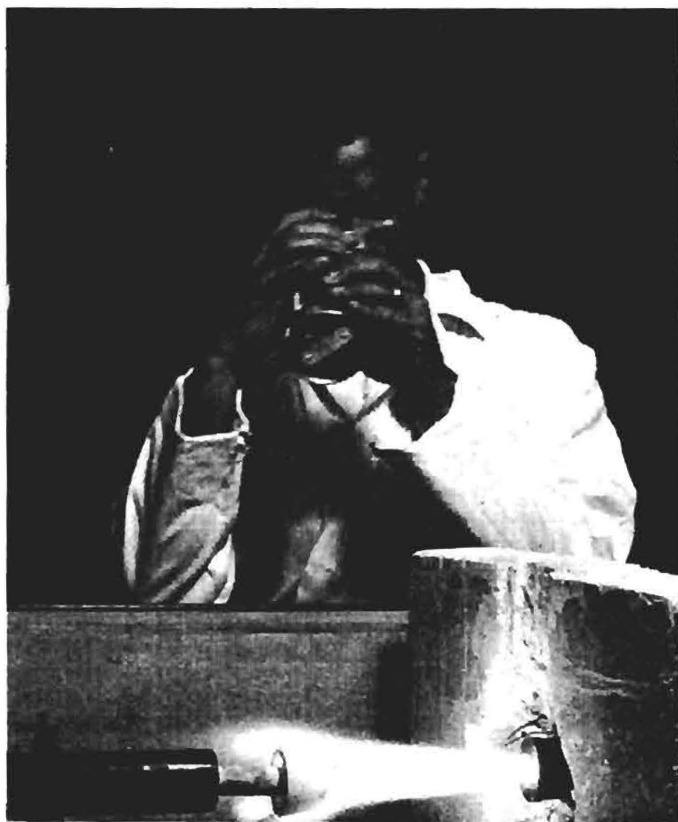
Alpha Kappa Psi Scholarship Award

The Epsilon Sigma Chapter of Alpha Kappa Psi, a professional business fraternity, awards annually the Alpha Kappa Psi Scholarship Key to the male senior student pursuing a degree in the School of Industrial Management, who has attained the highest scholastic average for three years of collegiate work at Georgia Tech.

Ernest Boggus Award

This award is made annually by the Surveying and Mapping Society of Georgia to an outstanding senior in civil engineering who is majoring in surveying and photogrammetry. The student is recommended by the civil engineering faculty.

3/ Information for Graduate Students



General Information

The faculty of the Georgia Institute of Technology grants advanced degrees in engineering, science, management, architecture and city planning through the Division of Graduate Studies and Research.

The goals of the division are to establish an educational environment that will encourage and assist students to develop their capabilities both as professionals and as human beings, to encourage students and faculty to press research vigorously for the discovery and generation of new knowledge, to investigate ways of applying such knowledge innovatively for the benefit of society and mankind and to foster the development of creative skills required for the design and development of new tools, objects and ideas.

Graduate study is particularly recommended for those students whose interests and aptitudes carry them beyond routine application. It may be undertaken either to broaden knowledge of a given field or to increase competence and interest in independent research. It is for the student who wishes to work in research, development, design or consulting; it is for the student of management who aspires to the formulation as well as the administration of policy and it is for those who desire to enter the profession of education in the fields of engineering, science or management.

Degrees and Programs of Study

Doctoral Programs

Programs of study and research leading to the Ph.D. degree are offered in the following disciplines.

Aerospace Engineering
Ceramic Engineering
Chemical Engineering
Chemistry
Civil Engineering and Sanitary
Engineering
Economics
Electrical Engineering
Engineering Science and
Mechanics
Geophysical Science

Industrial and Systems Engineering
Industrial Management
Information and Computer
Science
Mathematics
Mechanical Engineering
Nuclear Engineering
Physics
Psychology
Textile Engineering and Science

Master's Programs

Programs of study and research leading to the Master of Science degree are offered in the following disciplines.

Aerospace Engineering	Industrial and Systems Engineering
Applied Nuclear Science	Industrial Management
Applied Physics	Information and Computer Science
Architecture	Mathematics
Biology	Mechanical Engineering
Ceramic Engineering	Metallurgy
Chemical Engineering	Nuclear Engineering
Chemistry	Operations Research
City Planning	Physics
Civil Engineering	Psychology
Electrical Engineering	Sanitary Engineering
Engineering Science and Mechanics	Textile Engineering
Geophysical Sciences	Textiles

Master of Architecture and Master of City Planning degrees are also available.

See detailed description of programs and courses under appropriate school designations.

Degrees may be awarded with or without designation of the field, based upon the recommendation of the school concerned.

City Planning also offers joint programs with the School of Civil Engineering, the School of Architecture and the University of Georgia School of Environmental Design. Each of these joint programs leads to the simultaneous awarding of two master's degrees.

Special Programs

Interdisciplinary Programs

All graduate degrees are offered through the channels of the several schools of the institute authorized to offer such degrees. Within this framework, however, arrangements are available for offering special study and research programs for students who desire to pursue a degree within a wider perspective than that of a single discipline.

Programs of this type are available through cooperation with the bioengineering, environmental resources and health systems research centers and through several informal programs based on interests of small groups of faculty in such areas as atomic

collisions, complex systems design, radiological health, solid waste technology, transportation and surface science technology.

Courses for Secondary School Teachers

Recognizing that the systems of secondary and higher education in the state of Georgia are mutually supportive, Georgia Tech offers a limited number of courses at the graduate level designed to prepare high school teachers to provide instruction in selected areas of science, engineering and technology. Courses are restricted to areas uniquely available, or available in unusual strength, at Georgia Tech.

Credit for satisfactory performance is recorded in the Office of the Registrar in the usual manner, but may not be counted toward any degree currently offered at Georgia Tech.

Interested persons should consult officials of the appropriate colleges and departments for details.

Many high schools are introducing courses dealing with engineering and environmental concepts to provide their students with a more realistic understanding of modern technology and its implications for contemporary society. The courses designed to instruct teachers in the teaching of such courses as a part of the high school curriculum are Engr. 6970, Engineering Concepts: Environmental Protection (2-3-3) and Arch. 6741, Environmental Awareness (5-0-5).

Policies and Regulations

The graduate council is responsible for establishing policy for the graduate program. With the approval of the academic senate, it reserves the right to change requirements for degrees as may be appropriate. Students who are enrolled at the time such changes are made shall have the privilege of following either the regulations stated in the catalog effective the quarter in which they enrolled, or the regulations in the catalog which records the change.

The institute-wide policies and regulations that govern the graduate program are recorded in this catalog. The several schools may make additional rules concerning programs and the pursuit of degrees in their schools, but these rules may not contradict institute policies and regulations.

Graduate Student Work Loads. The minimum hours for which a student may be enrolled is three. The maximum hours for which he may be enrolled is 18. A full-time student must be enrolled for 12 hours. The special regulations concerning the number of hours

of enrollment for students who hold assistantships or fellowships or who work on a full- or part-time basis are on file in each school and the division office.

Staff Members. No staff member beyond the rank of instructor will be permitted to work for a master's degree in the school in which he serves.

No new staff member with the rank of assistant professor will be permitted to work for a doctoral degree in the school in which he serves.

Admissions Information

All correspondence concerning admission to graduate study should be directed to the appropriate school. Necessary admission forms may be obtained from the appropriate school or from the Division of Graduate Studies and Research. These forms, together with letters of recommendation and official transcripts of previous academic work, should be on file at the institute at least four weeks before the beginning of the term for which the applicant plans to register.

Graduate Record Examinations

Applicants may be required by the director of their school to submit results of the Aptitude and Advanced tests of the Graduate Record Examinations (GRE).

Students applying to the schools of biology, geophysical sciences, psychology and industrial and systems engineering (operations research program only) are required to submit GRE scores. Applicants to the School of Mathematics must take the Aptitude and Advanced tests of the GRE. All scores should be sent directly to the school and not to the graduate division. Students applying to the College of Industrial Management are required to supply Admission Test for Graduate Study in Business (ATGSB) scores and should have these scores sent directly to the dean of the College of Industrial Management.

Information as to time and location at which these tests are given can be obtained by writing to Graduate Record Examinations, Educational Testing Service, Box 955, Princeton, N.J., 08540. Inquiries from students in western states should be addressed to 1947 Center Street, Berkeley, California, 94704.

Information on the ATGSB test may be obtained by writing the Educational Testing Service, Box 966, Princeton, N.J., 08540.

Types of Standing

Full graduate standing will be accorded those applicants holding a bachelor's degree from an approved institution whose previous work has been of a nature and quality sufficient to offer reasonable assurance of immediate success in advanced study.

Conditional graduate standing will be granted to applicants holding a bachelor's degree from an approved institution whose previous work, because of deficiencies either in content or quality, must be supplemented by additional work or demonstrated ability to be performed at a specified level.

Admission to the Division of Graduate Studies and Research as a *special graduate student* may be granted to students who do not wish to qualify for an advanced degree at Georgia Tech, but who can demonstrate that the pursuance of certain advanced work will be of real benefit to them.

Students working toward a second bachelor's degree will be registered in the undergraduate school.

Students who are graduate students in good standing at another university may be admitted as *transient graduate students* after filing an application and verification of good standing status. The work undertaken will not be applicable toward a Georgia Tech degree.

The Georgia Institute of Technology reserves the right to deny entrance to any applicant without showing cause.

Readmission

A student who interrupts the continuity of his graduate program by not registering for one quarter (summer quarter excepted) must seek readmission by filing with the registrar a completed request for readmission form at least twenty calendar days prior to the beginning of the quarter in which readmission is sought. Request forms are available from the registrar's office.

Reactivation of Application

Students who have been admitted for graduate study at Tech but do not enter in the quarter for which they applied and subsequently wish to be considered for a later quarter *must* reactivate their application for the new quarter. Since files are kept by the graduate office and the registrar's office for only one year on "never entered" students, these students will have to supply a whole new set of application materials if they delay more than one year in the reactivation request. To reactivate an application the student must request reactivation in writing to the registrar no

later than twenty days before the registration date for the new quarter.

Undergraduate Students

Exceptionally well qualified undergraduate students may schedule in their senior year graduate courses provided they have the permission of the director of their school.

Credit toward the master's degree for work by undergraduates will be allowed only under the following conditions.

1. The student must have been in residence at the Georgia Institute of Technology for at least two quarters before registering for the course for which he desires graduate credit.

2. Credit for the course must not have been applied toward an undergraduate degree.

TOEFL for International Students

Test of English as a Foreign Language (TOEFL) is required of all international students coming from countries in which English is not the native language. The student should arrange to have the Educational Testing Service send test results to the registrar's office as early as possible, for this information constitutes a part of the material reviewed for admission to graduate study at Georgia Tech. Students who make low scores will be required to take remedial work in English before being classified in full standing.

Students who wish to take TOEFL in any country *except* Hong Kong, India, Nepal or Taiwan should obtain the *TOEFL Bulletin of Information for Candidates, International Edition*. Copies of this *Bulletin* and the registration form may be obtained in a number of cities outside the United States. They often are available at American embassies and consulates, offices of the United States Information Service (USIS), United States educational commissions and foundations abroad and binational centers. In addition, several private organizations distribute *TOEFL Bulletins*. Among them are 1. the Institute of International Education (IIE) in Nairobi, Kenya; Paris, France; and Lima, Peru; 2. the African-American Institute (AAI) in Dar es Salaam, Tanzania; and Lagos, Nigeria; 3. the American Friends of the Middle East (AFME) in Tehran, Iran; Amman, Jordan; Beirut, Lebanon; Tangier, Morocco; and Cairo, Egypt; and 4. the American-Korean Foundation in Seoul, Korea.

Students who cannot obtain locally a *TOEFL Bulletin of Information for Candidates, International Edition* and registration form should write for them well in advance to Test of English as a Foreign Language, Box 899, Princeton, New Jersey, U.S.A. 08540.

Registration

Official registration dates will be found on the calendar page of this bulletin. New graduate students must report first to their school at 8:00 a.m. on registration day, where further instructions regarding registration procedures will be made available.

Each new graduate student must plan for an interview with the director of his school of specialty during the week before registration to prepare the proposed program of graduate study.

The division conducts an orientation for new graduate students in the fall quarter just before registration.

The Master's Degree

Prerequisites

The applicant will be expected to hold a bachelor's degree from a recognized institution, and to have graduated in the upper half of his class. He will be asked to show proof of preparation in his chosen field sufficient to ensure profitable graduate study.

Matriculation Requirements

A student is matriculated for a graduate degree when he has been admitted to the Division of Graduate Studies and Research with either full or conditional standing. He must be classified as having "full graduate status" in order to graduate with the M.S. degree.

Students who have matriculated for the master's degree are required to maintain continuous matriculation if the original requirements for the degree remain unchanged. If continuous matriculation is not maintained, the student's credentials are subject to re-evaluation and additional requirements for the degree may be imposed.

Continuous matriculation will be maintained by the student if he is officially registered for at least one quarter per calendar year during the period of six years following his original admission.

If a student has completed all of his course work and is planning to submit a thesis in partial fulfillment of the requirements for a master's degree, he should register for research hours consistent with a realistic appraisal of the amount of work yet to be done on the thesis and the amount of faculty involvement required. The student is not entitled to receive thesis guidance during any quarter in which he is not registered.

A minimum of one full academic year or its equivalent in residence at the Georgia Institute of Technology is required for the master's degree. This residence need not be gained in consecutive terms, but the entire program toward the degree must be

completed within a period of not more than six consecutive calendar years.

Twelve credit hours per quarter, excluding audit hours, will be considered the minimum for which full residence credit may be granted. Lighter schedules will be prorated on this basis in computing residence gained.

Academic Requirements

Thirty-three quarter hours of approved work in courses beyond the bachelor's degree, plus a thesis, are required for the master's degree. With the consent and approval of the director of the school in which the student is registered, 17 additional quarter hours of work in courses at the 6000-7000-8000 level, of which nine hours are in the student's major field,* may be submitted in lieu of a thesis.

A student must earn a graduate grade average of at least 2.7 and satisfy other requirements of his school before he may be certified for a master's degree. Grade points are given for all courses in which grades are reported. They are computed as follows: for each credit received in a course, 4 grade points are granted if the grade is A, 3 if B, 2 if C, 1 if D and 0 if F. The graduate average includes the grades on all courses scheduled by the student after being admitted to the graduate division, plus the grades on all courses listed on the student's approved program of study which have been earned at Georgia Tech prior to his admission to graduate study.

At least 18 quarter hours of work in courses, not including a thesis (or courses submitted in lieu of a thesis), must be taken in the student's major field.* Required undergraduate courses in the student's major field may not normally be used for graduate credit. At least 18 quarter hours of the student's program must be in courses numbered from 6000 to 8999, not including those courses which may be submitted in lieu of a thesis. No graduate credit will be given for any course not approved by the school, graduate council and academic senate.

The student, in conference with his faculty adviser, should prepare a program of study for the master's degree as a guide in planning his academic schedule. According to the requirements of the school in which he is enrolled, the student may be required to submit this program to the director of the school. The student must submit to the dean of the Division of Graduate Studies and Research before the end of the second week of the quarter in which he expects to complete the requirements for the degree an approved program of study.

*The term "major field" as used in these regulations indicates a basic field of knowledge rather than a department of specialization.

Admission to Candidacy for the Master's Degree

Admission to graduate standing does not constitute acceptance as a candidate for an advanced degree. To obtain consideration for this privilege the student must have shown evidence of ability to pursue a program of graduate study and research. A mere accumulation of credits is not sufficient. A petition for a degree (forms available in the registrar's office) is to be submitted to the registrar during the quarter prior to the final quarter in which the work for the degree is to be completed. To receive favorable action on this petition, the applicant must ordinarily have met the following requirements:

1. He must show that he will have satisfactorily completed course requirements for the master's degree in accordance with the following table.

Course and Scholarship Requirements for the Master's Degree

	Minimum Hours in Major Field	Minimum Hours at 6000-7000 Level	Total Required Credit Hrs.
With thesis	18	18	33
Without thesis*	27	35	50

2. He must have completed, or be scheduled to complete during the quarter, any required non-credit prerequisite work outlined at the time of his matriculation.

3. He must have an overall grade point average of at least 2.7 and satisfy the requirements of his school.

4. He must have completed satisfactorily any language requirement imposed.

5. He must have passed any qualifying or comprehensive examinations required by the department in which he is registered.

6. He must have filed with the Division of Graduate Studies and Research an approved thesis topic and have made satisfactory progress on his thesis if it is a part of his program.

Academic Requirements

Requirements for Award of the Degree. The graduate council may recommend to the academic senate the awarding of the master's degree to the candidate who complies with the following requirement:

1. has an overall grade point average of at least 2.7 and has satisfied the requirements of his school,

2. receives final acceptance of his thesis from the division and deposits three unbound copies with the library,

3. supplies the division with a publishable abstract of his

*Must have approval of school director.

thesis, up to 300 words, the accuracy of which has been certified by the thesis adviser,

4. presents an approved program of study (complete within a period of not more than six consecutive calendar years) to the dean of the Division of Graduate Studies and Research in accordance with the deadline set forth in the institute calendar for the quarter,

5. passes any general examinations, oral or written, required by his school, and

6. is, at the time, a registered student.

Language Requirement. A reading knowledge of one appropriate foreign language may be required at the option of the school in which the student is registered. Foreign students will be expected to show adequate mastery of English.

Transfer of Credit. The rules relative to and the process for obtaining transfer of credit for graduate level courses are as follows.

a. Transfer credit can be obtained for graduate level courses taken elsewhere in the United States if they have not been used for another degree. A current transcript is required for this evaluation.

b. A maximum of nine quarter hours can be petitioned for under the guidelines set forth by the graduate council. Exceptions to this maximum must be brought before the council or the executive committee of the council except as noted below.

c. Students may be allowed to receive graduate credit for up to one-third of the hours required for the degree for graduate courses taken at Emory University or Georgia State University, provided such courses 1. are not offered at Georgia Tech, 2. are approved in writing in advance by the student's adviser and school director, and 3. are passed with a grade of C or better. Requirement two is satisfied when the courses appear on the student's proposed program of study.

d. The processing steps that must be followed in all cases are the following.

1. The student must confer with his graduate adviser to ascertain whether the courses to be transferred are a logical part of the student's graduate program. The courses would typically be those appearing on the approved program of studies form for the master's program student. A doctoral program student would normally not be seeking transfer of credit.

2. If the courses are appropriate, he should take a copy of the current transcript that shows the courses, appropriate descriptive materials, such as catalog description and textbook used, to the school on this campus that teaches or comes close to teaching the courses. These courses must be evaluated

by a member of the appropriate faculty who will indicate the number of credit hours and the Georgia Tech counterpart. The professor should prepare a transfer credit form, and if he is not the school director, the school director should cosign it. The transfer credit form should then be sent directly to the graduate division if for more than nine hours, otherwise it should be sent directly to the registrar.

3. Finally, the student must write a petition to the dean of the graduate division indicating his wishes relative to the courses. On this petition there must be a place for recommended action by the student's school director. The transfer credit forms do not eliminate the need for the letter petition. The transfer credit forms serve as documentation for the contents of petition.

The Master's Thesis

A master's thesis is a requirement for the master's degree except in those cases where the director of the school in which a student is registered may consider additional course work of more importance in meeting the student's approved objective.

Students who meet the requirements for the master's degree by completing a combination of course work and thesis are required to register for a minimum of seventeen hours of credit in thesis. (See section above on matriculation requirements.)

A candidate whose program includes a thesis must present a treatise in which are set forth in good literary form the results of an investigation directed by a member of the faculty of the institute. The purpose of the thesis is to further the educational development of the student by requiring him to plan, conduct and report an organized and systematic study of importance.

The Manual for Graduate Theses, available from the Division of Graduate Studies and Research, explains the requirements for the thesis.

The Doctoral Degree

The degree of Doctor of Philosophy is basically a research degree awarded in recognition of demonstrated proficiency and high achievement in research. After adequate preparation the candidate must complete a searching and authoritative investigation of a special area in the field of his choice, culminating in a written dissertation covering that investigation. The dissertation must be either an addition to the fundamental knowledge of the field, or a new and better interpretation of facts already known. It must demonstrate that the candidate possesses power of original

thought, talent for research and ability to organize and present his findings.

Matriculation Requirements

Ordinarily a student will be admitted to the Division of Graduate Studies and Research for the purpose of studying for the doctorate only if he has graduated in the upper quarter of his class. This requirement may be modified for those who have shown unusual promise in their work toward a master's degree.

Except for this restriction, the requirements for entrance to the division with the purpose of working towards the doctorate are identical to those outlined for the master's degree.

At least three full-time quarters must be spent in residence at the Georgia Institute of Technology. Ordinarily research for the doctoral dissertation must be carried out while in residence on the campus. However, when the candidate has met the residence requirements he may be permitted under special circumstances to pursue further work in absentia if done under the direction of a faculty member and approved by the dean of the Division of Graduate Studies and Research as well as the director of the school concerned.

Admission to Candidacy

Admission of a student to candidacy for the doctorate is based primarily upon the passing of certain comprehensive examinations. These examinations have for their objective the testing of the student's knowledge of the general field in which he is to receive his degree, as well as the specialized portion of this field in which his research is being carried out. In general, the student will find it advisable to complete at least five quarters of course work beyond the B.S. degree in order to provide himself with an adequate background before taking these examinations.

The comprehensive examination will normally be given at least once a year, in the fall or in the spring. The examinations will be given by and are the responsibility of the school in which the student is to receive his degree. The student shall be informed of the scope of the examinations.

Students will be guided in the planning of a program of study and in the preparation for these examinations by a guidance committee appointed by the director of the school. The duties of the committee shall include 1. evaluation (by personal consultation) of the background and interests of each entering student, 2. aiding the student in planning his course work, taking into account his special circumstances and 3. consultation with the stu-

dent from time to time for purposes of evaluating and aiding his progress.

The student will be expected to take examinations in all courses in which he is regularly enrolled. His grades in these courses will be reported in the usual manner to the Office of the Registrar.

The student must satisfy the following requirements prior to admission to candidacy for the degree.

1. The comprehensive examinations must have been passed.

2. The student must have filed with the director of his school and the dean of the Division of Graduate Studies and Research a formal statement naming his thesis adviser and setting forth the topic he has selected for his research, the purpose of the investigation, and the steps by which he proposes to conduct it.

Upon satisfactory completion of these requirements, with approval of the thesis topic, the applicant may be formally admitted to candidacy for the degree.

A petition for a degree is to be submitted to the registrar during the quarter prior to the final quarter in which the work for the degree is to be completed. Petition forms are available in the registrar's office.

The requirements for the degree must be completed within five years from the end of the quarter in which the candidate passes his comprehensive (qualifying) examinations.

Major and Minor Fields of Study

While there are no fixed course requirements for the doctorate, the student will be expected to pursue both a major and a minor field of study. The student's program will usually require two or more years of course work beyond undergraduate study.

In addition to an adequate knowledge of the major field in which his research is to be carried out, each student will be required to demonstrate a mastery of some other, smaller body of knowledge within or, preferably, outside his school. This area of study is referred to as a minor field. The purpose of the minor is to encourage a wider interest on the part of the student and to provide a broader basis for the evaluation of his capabilities.

The minor will normally consist of at least 15 quarter hours of work in related courses, chosen by the student in consultation with his guidance committee. The proposed minor must be approved by the dean of the Division of Graduate Studies and Research prior to its completion. After the minor is satisfactorily completed, this fact should be transmitted to the graduate division accompanied by the grades in the courses for final approval and recording.

Completion of the minor is not a prerequisite for admission to candidacy, but it must be approved and completed before clearance for the degree.

Languages

Every doctoral candidate is required to have had exposure to some cultural and functional aspects of foreign languages before being granted the degree. He may satisfy this requirement by any one of the following options.

1. Pass two years of course work in foreign language at the college level with an average grade of C or better. This may include one year each in two different languages or two years in one language. Every two years of foreign language course work in a particular language in secondary school will be considered equivalent to one year of college course work.
2. Enroll in one of the following sequences of courses and earn an average grade of C or better.
 - a. Fren. 4075-4076-4077 Intensive Readings in French.
 - b. Ger. 4075-4076-4077 Intensive Readings in German.
 - c. Russ. 4075-4076-4077 Intensive Readings in Russian.
 - d. Span. 4075-4076-4077 Intensive Readings in Spanish.
 - e. Ling. 4075-4076-4077 Languages for Science and Technology.
3. Petition for and pass a written equivalency test in one foreign language administered by the Department of Modern Languages in lieu of formal course work. The proficiency level expected is comparable to that of a student just completing the present second-year language course in the Department of Modern Languages with a grade of C or better.
4. Present evidence of other experiences that clearly demonstrate an exposure to cultural and functional aspects of foreign language equivalent to the above, such as having been reared and educated in a mother tongue other than English.

It shall be the authority of the Department of Modern Languages to evaluate and certify to the graduate division the satisfactory completion of the above foreign language requirements for each candidate. If the student wishes to satisfy the language requirement using alternative 1 or 4, he must supply complete official records and English translations of such records when appropriate.

Additional requirements of proficiency in reading or translating scientific literature in one or more foreign languages may be imposed by an individual school at its discretion.

The Dissertation

Prior to his admission to candidacy the candidate will present for the approval of the director of his school and the dean of the Division of Graduate Studies and Research a formal statement naming his dissertation adviser and setting forth the topic he has selected for investigation, the objectives he hopes to gain and the steps by which he proposes to gain them. The dissertation topic must give promise of being either a genuine addition to the fundamental knowledge of the field or a new and better interpretation of facts already known.

Instructions concerning the dissertation are obtainable from the office of the Division of Graduate Studies and Research. All dissertations are microfilmed and deposited with the University Microfilms Service. A charge of \$25 must be paid by the student to the institute for this service.

The Doctoral Examination

If the Dissertation Advisory Committee finds the dissertation satisfactory, the candidate will be called for an oral examination on the subject matter of the thesis and the field in which it lies. The examination will be made by an examining committee appointed by the dean of the Division of Graduate Studies and Research. The student must be registered during the quarter in which the final examination is given and in the quarter in which he graduates.

If both the dissertation and the examination are satisfactory and the requirements of residence, languages and the minor field have been complied with, the candidate will be certified as qualified to receive the degree of Doctor of Philosophy.

In case of a failure on the final oral examination the result will be reported to the dean of the Division of Graduate Studies and Research and the director of the candidate's school. On recommendation of the examining committee one additional examination will be permitted. In case of failure no report of the result of the examination will be sent to the registrar, but a record will be kept in the office of the dean of the Division of Graduate Studies and Research.

Additional requirements for the doctorate may be added by the schools at their discretion.

Financial Information

Costs

Note: conditions may arise beyond the control of the Georgia

Institute of Technology which will cause the rate for tuition, fees, board and room to be changed during the next year without notice.

The following schedule of matriculation, tuition, student activity and other fees is effective for the 1974-75 academic session.

	Matriculation Fee Per Quarter	Tuition Fee Per Quarter	Student Activity Fee Per Quarter	Medical Fee Per Quarter	Total Fee Per Quarter	Total Fees Per Academic Year
Residents of Georgia	\$145		\$18	\$20	\$183	\$549
Nonresidents of Georgia	\$145	\$295	\$18	\$20	\$478	\$1434

An extra fee may be charged in special courses.

Graduate students carrying a full academic load (12 credit hours or more per quarter) will be charged the full amount of all fees as shown above.

Part-time students (those carrying less than 12 credit hours per quarter) who are legal residents of Georgia will be charged \$12 per credit hour in satisfaction of the matriculation fee and \$38 for the student activity and medical fees unless the student is carrying less than six credit hours. For these students only the matriculation fee is charged. All other graduate students will have an additional tuition fee of \$25 per credit hour. The minimum number of hours a student may enroll for is three.

Graduate students who have completed the residence requirements for the degree may register for research only at the rate of \$12 per designated equivalent credit hour. Hours for which the student is registered shall be consistent with a realistic appraisal of the amount of work yet to be done on the thesis or dissertation and the amount of faculty involvement required. Such registration carries no residence credit and must be approved by the Division of Graduate Studies and Research.

Other Fees. Each person receiving a diploma must pay a diploma fee of \$8 before graduating. A candidate for the doctoral degree must pay a charge of \$25 for microfilming his dissertation and depositing it with the University Microfilms Service.

The cost of binding the three library copies of a student's thesis or dissertation is borne by the institute.

A late registration fee of not more than \$16 is charged at the rate of \$10 for the first day after regular registration, and an additional \$2 for each of the next three days.

Refund of Fees. The institute has an established set of rules governing the refund of fees to students who must drop out of school. See page 29.

Financial Assistance

The institute offers financial aid from a variety of sources to assist students with the pursuit and completion of their degree as rapidly as circumstances permit.

Inquiries for financial aid should be addressed to the director of the school in which the student plans to study.

Graduate Research Assistantships. These awards are ordinarily offered students on a one-third or half-time basis. However, awards of a greater or lesser amount may be offered according to the needs of the respective school, departments and centers or divisions of the Engineering Experiment Station.

Graduate Teaching Assistantships. These awards are ordinarily offered on a one-third or half-time basis. However, awards of a greater or lesser amount may be offered according to the needs of the respective schools and departments.

Part-Time Instructorships (Non-faculty). Graduate students qualified to teach or assist in teaching at college level who wish to obtain experience and advance themselves in the field of science and engineering education may be appointed part-time instructors. Their duties will consist of part-time teaching under the direction of experienced engineering and science educators. These positions do not carry academic rank. Stipends for the nine-month academic year will be in proportion to the teaching load.

Federal Fellowships and Traineeships. The institute awards a number of fellowships and traineeships through participation in programs sponsored by agencies of the federal government.

In addition, traineeships associated with specific training programs are available as follows: water resources planning and management through the Environmental Resources Center, solid waste training program through the School of Civil Engineering, radiation health specialist training program through the School of Nuclear Engineering, environmental health through the School of Civil Engineering and air quality control through the School of Chemical Engineering.

Tuition Waivers. Nonresident graduate students who hold assistantships or work for the institute in a professional capacity on at least a one-third-time basis may register on payment of resident fees. In addition, there are available a limited number of tuition waivers for award to qualified out-of-state students upon recommendation of the school director. Preference will be given to those students taking 12 hours or more of courses for credit and having an outstanding academic record. Full-time students sponsored by WSF, AFGRAD, LASPAU and certain IIE students

may carry top priority if Georgia Tech has given an institutional commitment to the group or agency. Since there are usually many more people recommended than the 40 waivers will support, grade point averages will be used in determining the final allocation of awards by the dean of the Division of Graduate Studies and Research.

Local Industry Work-Study Programs. Many industries located in and around Atlanta offer opportunities to pursue graduate degrees as an integral part of their employee training programs. In such a plan, the student may work and study on a reduced work week schedule that is compatible with school, student and company requirements. Academic fees, costs of texts and a supply allowance may be paid by the company.

Graduate Employment. Appointments of graduate students in the Engineering Experiment Station may be made on the recommendations of the director of the school in which the student is registered, the director of the experiment station and the dean of the Division of Graduate Studies and Research. Graduate students are appointed as graduate research assistants. They may participate in investigations which are conducted in the experiment station on the subject of a thesis, provided the subject is acceptable to the school director concerned and the degree of responsibility borne by the student is considered sufficient. Approval of the thesis topic is the prerogative of the dean of the Division of Graduate Studies and Research.

Veterans Program. Most veterans who served on active duty for more than 180 days, any part of which occurred after January 31, 1955, are eligible for financial support to attend college.

Generally, sons and daughters between 18 and 26 years old of deceased veterans and those of living veterans who have disabilities which are considered to be permanent, whose death or disability was a result of service in the armed forces, are eligible for financial benefits under the veterans program to attend college.

If a prospective student has never before received any benefits for education from the Veterans Administration, he will need to go to their office and fill out the necessary forms. It is important that the student carry with him file C number, discharge papers and legal proof of any dependents, such as marriage license, birth certificates etc.

Once the basic application and legal papers have been forwarded to the VA they will be processed and the student will be sent a certificate of eligibility. This item should be given to the Georgia Institute of Technology on registration day for handling.

The Georgia Institute of Technology has assigned the respon-

sibility of the veterans program to the Financial Aid Office, located in the Administration Building on the Tech campus. After a student has completed registration for his first quarter at Georgia Tech, he should submit his certificate of eligibility to that office for processing. Generally, the first check is received not later than six weeks after the certificate has been submitted to the institution. Once payments have begun, they should continue on a regular basis for the period of approval.

Any questions or comments may be directed to the Financial Aid Office at Georgia Tech.

Sponsored Fellowships. The institute has a number of fellowships that are contributed by various industrial organizations, foundations and trust funds for the support of outstanding graduate students. These fellowships assist students in pursuing their studies and research full time. The name given each fellowship listed below indicates the donor or person(s) memorialized by the fellowship.

Atlantic Steel Company

A fellowship in chemical engineering, civil engineering or mechanical engineering in the amount of \$1,500.

Automotive Safety Foundation

A fellowship in highway engineering; tuition and matriculation fees, plus \$1800. Awarded on basis of national competition.

Burlington Industries Fellowship

A fellowship in the amount of \$5,000 awarded to the School of Textile Engineering be used to provide the fellow's stipend, tuition and research equipment and supplies.

Burroughs Corporation

Two scholarships of \$2,000 each to assist students whose goals are related to a career in industry.

Celanese Fellowship

A fellowship in textiles; tuition and matriculation fees, plus \$1,600; total grant \$2,500.

E. I. DuPont de Nemours & Company, Inc.

A grant of \$10,000 to be allocated to each of four schools, chemical engineering, chemistry, electrical engineering and mechanical engineering. It is to be used to enhance or maintain the strength of their instruction in science and engineering.

Eastman Kodak Fellowship

A \$6,000 grant to the textile school. Stipend not less than \$2,500 per calendar year or \$3,000 if there are dependents, plus tuition

and fees. Balance to be used as an unrestricted grant in the school.

G. B. Espy Faculty Bioengineering Fellowship

A fellowship to aid Georgia Tech professors in moving into the medical profession as bioengineers. To be eligible a person must be currently a member of the Georgia Tech staff, possess either a Ph.D. or Sc.D. in chemical engineering, electrical engineering, mechanical engineering or nuclear engineering, and at the time of application be accepted by a medical school as a full-time student in a program of study leading to the M.D.

Ford Foundation Fellowship

Fellowship and loan for doctoral studies in engineering. These awards are a combination of fellowship and teaching or research assistantships valued at up to \$3,000 plus tuition and fees and may be awarded for a calendar year including the usual vacation periods. Also, loans based on need up to \$3,000 annually will be available to well-qualified graduate students motivated toward academic careers. The loans will be cancelled at a minimum rate of \$1,000 per year for each full-time year of service in an academic career in the United States and Canada.

General Electric Foundation

A \$5,000 grant to the School of Mechanical Engineering.

Kaiser Financial Aid Grant

A grant of \$4,600 to the School of Chemical Engineering, \$3,600 to the recipient and \$1,000 to the school.

Loula D. Lasker Fellowship Trust

Graduate Fellowships in city planning. Awarded on a basis of national competition.

Richard King Mellon Charitable Trusts

Fellowships for graduate work in city planning. Preference is given to men and women who are working in the field of city planning and who recognize a need for further graduate training.

Edward Orton, Jr. Foundation Fellowship

A fellowship in ceramic engineering carrying a stipend of \$1,800 for twelve months study, plus \$200 for equipment and supplies.

Robert J. Painter Memorial Fellowship

A fellowship to be awarded to an outstanding applicant entering his final year of full-time graduate work leading to a doctoral degree in a field contributing to the science and knowledge of materials. \$5,000 to the fellow and \$1,500 to the institution. This grant will be awarded by June 1.

Robert & Company Fellowship

A fellowship to be used in civil, electrical or mechanical engineering; \$1,200 stipend. Recipient must be a native of Georgia.

Robert & Company Associates Fellowship

A fellowship in architecture; \$1,200 stipend. Recipient must be a native of Georgia.

Sandoz Foundation Inc.

A grant of \$5,000 awarded to the School of Textile Engineering to be used as a fellowship and supporting funds for tuition, equipment and faculty supervision.

Schlumberger Fellowship

Two fellowships in electrical engineering; tuition and fees, plus \$3,000 stipend; total grant \$5,500.

Shell Companies Foundation

A fellowship for graduate study in civil engineering; \$2,000 stipend academic year, \$2,500 calendar year (married students \$2,600 and \$3,200 respectively) plus tuition and matriculation fees; \$1,000 to the School of Civil Engineering.

Standard Oil Company of California

A fellowship in chemical engineering; tuition and matriculation fees, plus \$2,000 to the student if single or \$2,600 if student has one or more dependents; \$1,000 unrestricted grant to the school.

Mary White Staton Fellowship

A fellowship in all schools of instruction—recipient must be from Colombia, South America; stipend of \$2,000.

T. Earle Stribling Memorial Textile Fellowship Fund

A fellowship in textiles; tuition and matriculation fees, plus \$1,500.

Texaco Fellowship in Metallurgical Engineering

A fellowship to encourage graduate studies in metallurgical engineering. Awarded at the discretion of the Department of Metallurgy in the School of Chemical Engineering. Stipend is \$3,000 plus tuition and fees for a twelve-month period.

Union Camp Fellowship

A \$5,000 fellowship in chemistry and chemical engineering; tuition and matriculation fees, plus a minimum of \$250 a month to the student for a period of at least nine months, the remaining money to be used for department needs.

Urban Studies Fellowship

\$9,000 for the purpose of supporting two city planning and urban

studies fellows; \$3,000 to each fellow and \$3,000 to the school for a cost of education allowance.

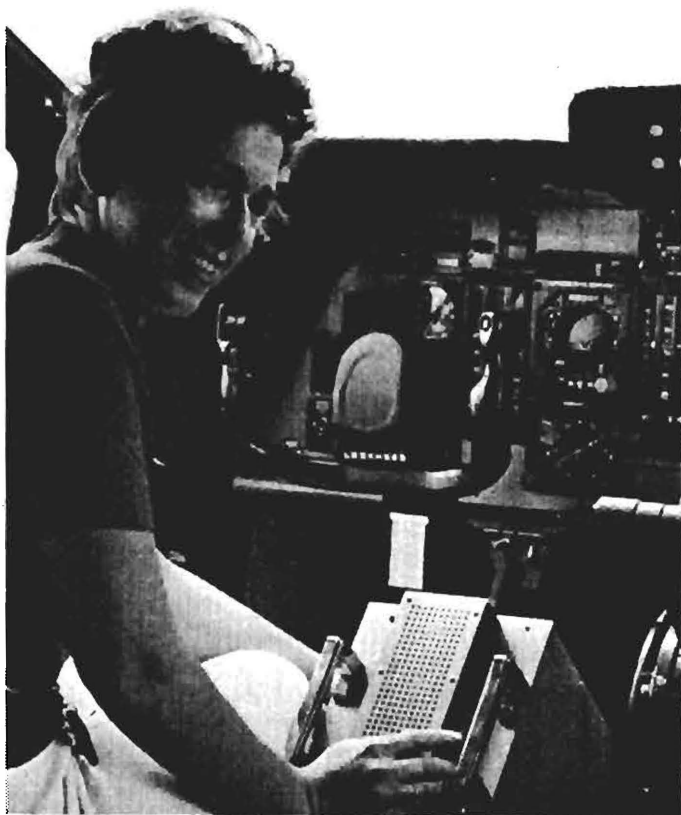
Whirlpool Corporation

Four graduate fellowships in engineering; \$2,400 stipend, plus tuition and fees.

Paul R. Yopp Fellowship

A fellowship in mechanical engineering to an outstanding graduate student covering a stipend, tuition and fees.

4/ Curricula and Degrees



TECH

College of Engineering

Freshman Engineering Electives

Any of the following courses are acceptable for credit as freshman engineering electives in all curricula in engineering: E.Gr. 1171, A.E. 1350, 1750, Cer.E. 1010, Ch.E. 1110, C.P. 1100, C.E. 1503, E.E. 1010, 1011, 1750, E.S.M. 1101, 1750, I.Sy.E. 1010, M.E. 1110, 1750, N.E. 1100, Text. 1100.

Multidisciplinary Programs In Engineering

Nine multidisciplinary educational programs provide unusual opportunities for specialized study in engineering at Georgia Tech. Eight additional programs under development already provide diversified opportunities in research, course work and seminars. These programs are designed for students to pursue the regular degrees while studying in one of the multidisciplinary areas. The multidisciplinary program is coordinated with normal degree requirements as to required and elective hours for the degree.

In addition to the established programs described in following sections, the following programs are under development: engineering design, environmental engineering, manufacturing engineering, materials engineering, ocean engineering, pulp and paper engineering, structures engineering and systems engineering. Additional information on these programs is available from the College of Engineering. Please specify your particular interest and educational level.

Acoustics Engineering. The acoustics engineering program provides an opportunity to obtain course work and research experience in the broad discipline of acoustics. The courses are offered in many schools of the institute, and are coordinated by the acoustics engineering committee. The student may specialize in a particular acoustics area such as aerodynamic noise, or he may select a broad program such as environmental noise management. Either master's or doctoral students may enter the program.

The participating schools are aerospace engineering, civil engineering, architecture, electrical engineering, engineering science and mechanics, mechanical engineering and psychology. Courses are offered in theoretical acoustics, aerodynamic noise, architectural acoustics, audio engineering, environmental noise management, industrial noise and psychoacoustics. Related courses exist in the areas of vibration control and seismology. The number of courses taken depends only upon the student's interest and the depth he desires in any particular area.

Current research opportunities exist in the fields of machinery

noise, combustion noise, aerodynamic noise, helicopter noise, atmospheric acoustics, propagation through multiphase media, environmental site design for low noise, near field-far field relationships, subjective response to noise and the effects of noise on human performance.

Bioengineering. The program in bioengineering provides the opportunity for students majoring in any one of a number of basic engineering disciplines to bring the special knowledge and techniques of their disciplines to bear on the problems encountered in biological and medical research and practice. The locale for practice in the field of bioengineering ranges from the research laboratory to the hospital clinic, with the engineer and the medical researcher or practitioner serving together as a team. Through appropriate selection of elective courses engineering students may orient their programs of study and research toward bioengineering at all three degree levels: bachelor's, master's and doctoral.

The following schools are currently participating actively in this program: aerospace engineering, architecture, ceramic engineering, chemical engineering, civil engineering, electrical engineering, engineering science and mechanics, industrial and systems engineering, mechanical engineering, nuclear engineering and textile engineering. Also participating is the Health Systems Research Center.

Computer Engineering. The computer engineering program is a master's degree program designed to provide engineers of all disciplines with the basic tools for computer applications in data acquisition, monitoring, control, simulation and problem solving as an integral part of their engineering capability.

The program is divided into two tracks. Track I is for the student interested in using computers as components in the design of on-line systems. The inclusion of this track is stimulated by the vastly reduced cost of mini-computer main frames. The course work emphasizes interface design, real-time programming and systems design for control application.

Track II is for the student interested in using the computer as a design and problem solving tool in an off-line environment. The emphasis in this track is on methods of using large and small computer systems in an efficient manner to solve engineering problems.

Course work in both tracks consists of 15 quarter hours. The schools currently participating in the program are aerospace engineering, civil engineering, chemical engineering, electrical engineering, industrial and systems engineering, mechanical engineering and nuclear engineering.

Educational Engineering. Educational engineering is a mul-

tidisciplinary program to educate engineers in the application of analytical concepts and experimental expertise to the creative solutions of problems in education. As a result, the educational engineer is trained to quantitatively plan, design and operate complex educational systems. He becomes capable of applying the skills and knowledge gained in engineering course work to the structure of the educational system. The training of a student in both education and engineering creates an intellectual bridge to improved methodology for educational planning and operation.

This program emphasizes engineering design, systems science, system dynamics and control, systematic planning, financial management and the learning process of human beings. The approach is typically multidisciplinary because the area of application requires competence in different specialized branches of knowledge.

The educational system is vast and complex, therefore the curriculum in educational engineering is designed to be flexible enough to accommodate a student's individual area of interest. The student is able to branch into a specialty area after having completed a series of core courses in psychology and in industrial and systems engineering. Fundamental technology and control concepts are joined with behavioral concepts to focus on learning and the educational system.

The educational engineering program has grown from natural concern for applying technology to areas of relevance to society as a whole. The allocation of human resources to education has always been a substantial part of the American heritage and their proper use has always been important. But the current complexities of educational institutions suggests that a systematic technological approach to educational problems would provide significant benefits for society. The educational engineer can be the means of effecting such benefits.

The schools presently participating in the educational engineering program are: civil engineering, electrical engineering, engineering science and mechanics, Industrial and systems engineering, mechanical engineering and textile engineering.

Energy Engineering. The multidisciplinary program in energy engineering is designed to educate engineers from various contributory disciplines in various aspects of the broad energy problem and its many ramifications. It provides an opportunity both for formal course work at the undergraduate and graduate levels and for the gaining of research experience. The program emphasizes the fundamental aspects of energy and deals with energy sources, fuels, conversion, transmission and utilization, as well as the treatment of effluents and waste heat. It deals also with the physical, technological, social, ecological and economic con-

straints and interrelationships within which engineering must operate. Participating schools are: aerospace engineering, chemical engineering, electrical engineering, mechanical engineering, nuclear engineering and engineering science and mechanics. Current research opportunities related to the energy engineering field are available in all of these participating schools. They range from the fundamentals of multiphase flow and transport through fixed and variable minor solar collectors through the design of hybrid environmental control systems to fundamental characteristics of high temperature, high pressure plasmas and their associated electrical phenomena.

The diminishing availability and increased cost of fuels, together with growing concern for environmental protection, places a great demand upon the ingenuity of engineers involved in this field of application.

Mineral Engineering. The multidisciplinary program in mineral engineering is designed to equip students from a variety of contributory engineering disciplines to deal with various phases of mineral usage, ranging from initial exploration through the extraction stages, but stopping short of fabrication processes. The main operations are mining, mineral beneficiation and extraction processes. Individual student programs leading to master's degrees through one or another of the participating schools are designed to provide a basic understanding of all three categories of operation, as well as an understanding in depth of that one for which the student expresses a preference.

This program may be pursued by students majoring in any one of the four participating schools of ceramic engineering, chemical engineering, civil engineering or nuclear engineering.

The current industrial demand for minerals taxes both known mineral reserves and the supply of engineers trained to work with them. For this reason, the field of mineral engineering offers a real career opportunity to persons interested in the conservation and efficient use of expendable mineral resources.

Plastics Engineering. The plastics industry has been growing at an annual rate of 15 percent for two decades. In response to the engineering manpower needs of this dynamic industry, courses, research and design projects pertaining to plastics engineering are available to students in all engineering disciplines.

Course selection is based on the particular needs and interests of each student. Introductory courses include: polymer science and engineering I and II, polymer science and engineering lab, polymerization process analysis, plastics industry manufacturing policies, fiber spinning, drawing and texturing. Advanced courses include: polymer structure and physical properties I and II, preparation and reactions of polymers, energetics, kinetics,

polymer degradation, surface and solution properties of polymers and non-Newtonian fluids.

Research and design projects can be selected in the areas of plastic materials, fabrication, applications, marketing and economics to emphasize plastics engineering. Financial support can usually be obtained for thesis work on plastics.

The normal requirements of the major discipline must be satisfied to complete a bachelor's, master's or doctorate. Plastics courses and projects can be readily incorporated within the major engineering programs.

Transportation Engineering. The transportation engineer faces the challenge of providing safe and efficient movement of people and goods for an increasing and shifting population with a minimum of social, environmental and ecological disruption. Increasing traffic congestion, decreasing energy supplies and concerns about noise and air pollution have created an unprecedented demand for well-trained and innovative transportation planners and engineers. The multidisciplinary program in transportation engineering has been developed in response to this demand.

This program, which leads to a master's degree, is available to engineers of all engineering disciplines. More than 50 courses are currently being offered in transportation engineering and related fields. Included are courses in transportation planning, traffic engineering, highway design, water transportation, airport planning and design, control theory, operations research, acoustics and noise control, complex systems design and many related subjects. Programs of study are individually designed to accommodate each student's needs and interests.

Schools participating in this program are: aerospace engineering, architecture, civil engineering, electrical engineering, engineering science and mechanics, industrial and systems engineering and mechanical engineering.

Urban Engineering. Urban engineering is a multidisciplinary program offered by many schools of engineering at Georgia Tech. Urban engineering is the integrated application of engineering science and technology to problems of urban society.

It is thus concerned with the technological aspects of governmental agency and private industry functions such as education, housing, human resources development, natural resource management, public health, public safety, transportation, utilities, waste disposal and water supply.

The urban engineer provides technical and managerial expertise in the decision processes and implements the decisions once made. He must be knowledgeable in economics, systems analysis, urban government, organization and politics as well as in

technology. He must be able to bridge the communications gap for people in the urban area who are not technologically oriented.

The urban engineering curricula in the participating schools allow students to prepare themselves for technologically oriented careers sensitive to the needs of an urban society. The participating schools are aerospace engineering, architecture, civil engineering, chemical engineering, engineering science and mechanics, industrial and systems engineering and mechanical engineering.

School Of Aerospace Engineering

(Daniel Guggenheim School of Aeronautics)

(Established in 1930)

Director – Arnold L. Ducoffe; *Associate Director and Regents' Professor* – Robin B. Gray; *Regents' Professor* – Ben T. Zinn; *Professors* – Robert L. Carlson, Donnell W. Dutton, Howard D. Edwards, Sathyanavayana V. Hanagud, John J. Harper, Wilfred H. Horton, James E. Hubbartt, C. Gerald Justus, Robert F. Mabon, Howard M. McMahon, G. Alvin Pierce, Warren C. Strahle, James C. Wu; *Associate Professors* – Stanley C. Bailey, Louis H. Bangert, James I. Craig, Don P. Giddens, Lawrence W. Rehfield, Robert G. Roper, C. Virgil Smith, Jr.; *Assistant Professors* – Eugene A. Powell; *Instructors* – William A. Bell, Robert K. Sigman.

General Information

The School of Aerospace Engineering prepares students at the bachelor's, master's and doctoral levels for a career in vehicle engineering with primary emphasis on flight vehicles. The school is housed in three buildings having a floor space of 85,000 square feet with a majority of this space devoted to instructional and research laboratories.

Undergraduate Programs

The first two years focus on course work in the areas of chemistry, mathematics, physics, humanities and social sciences. Aerospace disciplines and related engineering sciences are emphasized in the third and fourth years. The undergraduate curriculum is designed to provide each student with a general background for either industry or graduate school at the end of four years. The program stresses both the theoretical and experimental aspects of aerospace engineering.

A certain degree of specialization is available to undergraduate students through the proper choice of electives or certain substitutions for required courses or both, depending on the student's abilities and career objectives. These specialized disciplines are acoustics, aeroelasticity, aerospace vehicle design, bioengineering, experimentation and instrumentation, fluid dynamics of pollution, helicopters and V/STOL aircraft, propulsion, structural dynamics, structures and supersonic and hypersonic vehicles.

A pre-med track is available to undergraduate students. This requires an additional academic year of chemistry and one academic year of biology. Students may substitute these courses for the electives and for certain required courses in the present curriculum.

Graduate Programs

The graduate programs at both the master's and doctoral levels are flexible so that students may tailor their course and research work to individual career objectives.

The following areas of specialty are available.

Aeroelasticity. Dynamic response and loads, flutter, servo-aeroelastic instabilities and control, static aeroelastic instabilities and loading, unsteady aerodynamics—V/STOL and conventional aircraft and vibrational characteristics of vehicles.

Environmental Dynamics. Air pollution simulation and meteorology, atmospheric simulation in the wind tunnel, ocean dynamics, planetary atmospheres, upper atmospheric reactions on aerospace vehicles and upper atmospheric winds and modeling.

Fluid Mechanics. Atmospheric boundary layer flows, computational fluid dynamics, helicopter aerodynamics, laminar and turbulent flows, plasma and reacting gas dynamics, rarefied gas flows, statistical theory of turbulence and V/STOL aircraft.

Propulsion. Combustion instability, external burning, propulsion system noise, solid rocket propellant research and supersonic combustion.

Structures. Buckling and postbuckling of structures, elastic and inelastic stress analysis, fracture mechanics, fatigue behavior, structural reliability and statistical methods of structural analysis, vibration and dynamic stability of structural elements, wave propagation and use of acoustic emission methods.

Urban and Societal Engineering. Air pollution, biomechanics, fire research and noise pollution.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Elective	E.Gr. 1170, Introduction to Visual Communication and Engineering Design I (2-3-3) and one of the engineering electives ¹	X-X-3	X-X-3	.....
Chem. 1101-2	Inorganic Chemistry	4-3-5	4-3-5	.....
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Phys. 2121	Physics	.....	.....	4-3-5
Electives ²	Humanities/Social Science/Modern Language	3-0-3	3-0-3	6-0-6
Electives ³	Free	1-0-1	1-0-1	1-0-1
Electives ⁴	Physical Education	0-4-1	0-4-1	0-4-1
	Totals	15-10-18	15-10-18	16-7-18

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
A.E. 2100	Structures I	.....	.....	4-3-5
A.E. 2600-1-2	Digital Computer I, II, III	1-0-1	0-3-1	0-3-1
E.S.M. 2201	Statics	3-0-3	.....	.....
E.S.M. 3201-2	Dynamics I, II	.....	3-0-3	3-0-3
Math. 2307	Calculus IV	5-0-5	.....	.....
Math. 2308	Calculus and Linear Algebra	.....	5-0-5	.....
Math. 2309	Ordinary Differential Equations	.....	.....	5-0-5
M.E. 3322	Thermodynamics	.....	.....	3-0-3
Phys. 2122-3	Physics	4-3-5	4-3-5	.....
Electives ²	Humanities/Social Science/Modern Language	3-0-3	3-0-3	.....
	Totals	16-3-17	15-6-17	15-6-17

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
A.E. 3000-1-2	Fluid Mechanics I, II, III	4-3-5	4-3-5	4-3-5
A.E. 3100-1-2	Structures II, III, IV	4-3-5	4-3-5	4-3-5
E.E. 3740	Instrumentation Laboratory	0-3-1	.....	.....
E.E. 3741	Electronic Systems	.....	0-3-1	.....
E.E. 3700	Circuits and Instruments	3-0-3	.....	.....
E.E. 3710	Electronic Systems	.....	3-0-3	.....
E.S.M. 4210	Mechanical Vibrations	.....	.....	3-0-3
Electives ²	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
	Totals	14-9-17	14-9-17	14-6-16

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
A.E. 4000	Fluid Mechanics IV	4-3-5	.....	.....
A.E. 4200	Vibration and Flutter	3-0-3	.....	.....
A.E. 4250	Jet Propulsion	.....	5-0-5	.....
A.E. 4350-1	Aerospace Engineering Design Project I, II	.....	2-6-4	2-6-4
A.E. 4500	Stability and Control	.....	5-0-5	.....
Math. 4582	Advanced Engineering Math	3-0-3	.....	.....
Electives ²	Humanities/Social Science/Modern Language	3-0-3	.....	6-0-6
Electives ⁵	Free	3-0-3	3-0-3	6-0-6
	Totals	16-3-17	15-6-17	14-6-16

¹ See College of Engineering section "Curricula and Degrees" for engineering electives.

² Eighteen credit hours in humanities and 18 credit hours in social science are required for graduation. To satisfy these requirements, humanities and social science courses must be selected from the College of Engineering listings in "Information for Undergraduate Students."

³ These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled.

⁴ See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women.

⁵ Free electives. Not more than nine credit hours of advanced ROTC may be applied toward the requirements for a degree.

School of Architecture

(Established in 1908)

Including the Departments of Architecture, Building Construction, Industrial Design and City Planning

Director—Paul M. Heffernan; *Emeritus Director*—Harold Bush-Brown; *Assistant Director*—Joseph N. Smith; *Regents' Professor*—Howard K. Menhinick (Emeritus); *Professors*—Arthur F. Beckum, Jr., Hin Bredendieck (Emeritus), Arnall T. Connell, Geoffrey G. Eichholz (part-time), John C. Gould (part-time), James H. Grady, Julian H. Harris (Emeritus), Malcolm G. Little, Jr., Demetrios A. Polychrone, Isaac E. Saporta (part-time), Richard Wilson; *Visiting Professors*—Pershing Wong (Fall), Jose Charlet (Winter), Sergio Lenci (Spring); *Associate Professors*—Stanley C. Bailey (part-time), Clifford R. Bragdon, Frank J. Clarke, Edward L. Daugherty (part-time), Dale A. Durfee, M. David Egan (part-time), C. Malcolm Gailey, Rufus R. Greene, John A. Kelly, F. Kemp Mooney (part-time), Robert J. Nichols, Elliott A. Pavlos, George H. Ramsey, Roger F. Rupnow, William J. Seay, Asit N. Sengupta (part-time), C. Virgil Smith (part-time), John A. Templar, Gene E. Willeke (part-time), Robert J. Young; *Assistant Professors*—Neill W. Connah, Dieter Franz (part-time), James B. Grant, John C. Hardy, Dennis E. Haskell, William W. Howell*, Rufus R. Hughes II, Michael A. Jones, Edward L. Keating, Ray E. Merritt (part-time), J. Kenneth Miller (part-time), Ivey L. Nix (part-time), Albert H. Smith, James C. Snyder, Elizabeth M. Strack (part-time), John E. Williams; *Instructors*—Gerald G. Birdwell, Robert S. Spain (part-time); *Lecturers*—Roy F. Kenzie (part-time), Andrew R. Greene (part-time), Joseph de Casseres Reshower (part-time), Louis F. Schneider (part-time); *Research Associate*—Bill B. Criswell.

General Information

The School of Architecture, established in 1908 as the Department of Architecture, was elevated to the status of a school

*On leave

in April, 1948 with the change in name of the institution to the Georgia Institute of Technology.

The original four-year curriculum led to the degree Bachelor of Science in Architecture, but in 1934 this was extended to a five-year program awarding the degree Bachelor of Architecture, which was offered as a first professional degree until 1972. For those students who matriculated before 1972-3 the Bachelor of Architecture is still available, but wherever possible they are encouraged to elect graduation under the new six-year program in architecture listed below, which will be mandatory for all entering students.

The four-year degrees, Bachelor of Science in Building Construction and Bachelor of Science in Industrial Design were established in 1958 following a period during which the curricula in these disciplines functioned as options under architecture. Recent changes in the content of these curricula take precedence over the listings in earlier catalogs.

The degrees Master of Architecture and Master of City Planning were initiated in 1952 and a joint degree program with the simultaneous award of both degrees has been in operation since 1969. Two-year joint degree programs between city planning and civil engineering (transportation) and city planning and environmental design (landscape architecture) at the University of Georgia are currently available.

The original aim and first objective of the school has been to prepare students for the profession of architecture. The scope of man's concern with the environment is of such breadth in current practice, however, that architects and planners not only must exhibit strength in the traditional role of building and space design but must reemphasize related interests in the social sciences and psychology, structural and mechanical systems, management of construction and field processes and economic and feasibility programming. Graduates with such grounding contribute effectively to teams that create and control the man-made environment at every scale, from the production of the smallest utilitarian object to community, city and regional planning. It is to this end that, over the years, the School of Architecture has embraced as many disciplines in design and planning as possible, not only to train its students in specialized fields but to liberalize and expand the training in architecture through their interaction.

Architecture

The undergraduate curriculum in architecture prepares the student through basic professional studies and general education to receive the degree Bachelor of Science (undesigned) at the

end of four years. It should be noted that this is not a professional degree in architecture and will not be recognized as such by the National Architectural Accrediting Board and the National Council of Architectural Registration Boards; accreditation will apply exclusively to the professional degree, Master of Architecture, awarded after two years of graduate study.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Arch. 1001-2-3	Design			
	Fundamentals	1-12-5	1-12-5	1-12-5
Arch. 1201-2-3	Architectural History	3-0-3	3-0-3	3-0-3
Math. 1307-8-9	Mathematics	5-0-5	5-0-5	5-0-5
Electives ²	Physical Education	0-4-1	0-4-1	0-4-1
Electives ¹		3-0-3	3-0-3	3-0-3
	Totals	12-16-17	12-16-17	12-16-17

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Arch. 2001-2-3	Architectural Design	1-12-5	1-12-5	1-12-5
Arch. 2301-2-3	Building Anatomy	3-0-3	3-0-3	3-0-3
Phys. 2111-2-3	Elementary Physics	4-0-4	4-0-4	4-0-4
E.S.M. 3701-2	Statics, Mechanics of			
	Materials	.....	3-0-3	3-0-3
Electives ¹		6-0-6	3-0-3	3-0-3
	Totals	14-12-18	14-12-18	14-12-18

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Arch. 3001-2-3	Architectural Design	1-12-5	1-12-5	1-12-5
Arch. 3321-2-3	Structures and Materials	4-3-5	4-3-5	4-3-5
Arch. 3401-21-41	Urban Planning, Facilities Planning, Building Economics	3-0-3	3-0-3	3-0-3
Electives ¹		3-0-3	3-0-3	3-0-3
	Totals	11-15-16	11-15-16	11-15-16

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Arch. 4001-2-3	Architectural Design	1-12-5	1-12-5	1-12-5
Electives ¹		12-0-12	12-0-12	12-0-12
	Totals	13-12-17	13-12-17	13-12-17

¹Electives

A total of 66 hours of electives are included in the undergraduate curriculum in architecture and, with the advice of faculty counselors, they should be programmed to include the categories below; these categories will satisfy the core curriculum requirements of the College of Engineering in the humanities and social sciences, additional professional requirements of the School of Architecture and will allow a degree of latitude for the student to plan toward specialization in the graduate program.

Humanities: nine credit hours are to be devoted to English literature courses, or to appropriate modern language courses at the 3000 level or above. Note that the architecture history sequence will satisfy the remaining nine credit hours of humanities requirements.

Social Sciences: 18 credit hours, including at least one course in each of sociology, political science and psychology.

General Electives: 39 credit hours may be structured to best further the student's professional goals, but must include at least six credit hours of advanced history and six credit hours in visual communication studio courses. Military training is an optional program of the institute, but in case basic ROTC and advanced military are elected, no more than 15 credit hours of general electives may be used for this purpose or will be credited toward the requirements for a degree.

²See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women.

Graduate Programs in Architecture

The regular two-year graduate program in architecture awards the professional degree, Master of Architecture, on completion of the credit hours listed below. Admission is obtained through the graduate division with approval of the School of Architecture; prerequisites are completion of the undergraduate Bachelor of Science curriculum at Georgia Tech or its equivalent in another school of architecture, plus an acceptable performance record. Concentrations are available in design, structures, urban design, health facilities and housing. Electives in the program will be employed to reinforce the student's option. A thesis is optional.

	<i>Quarter Hours Credit</i>	
	<i>Without Thesis</i>	<i>With Thesis</i>
Design or Special Problems Courses	45	36
Arch. 6301, 6321, 6442	9	9
Electives	36	30
Total	90	75

A one-year graduate program requiring 50 credit hours is also available for students who have completed a five-year Bachelor of Architecture degree. The two-year joint degree program with city planning, specializing in urban design, will award simultaneously both the Master of Architecture and Master of City Planning degrees.

Building Construction

As one of the major industries in the country, construction has need of many persons who are trained in the field of materials, manufacturing, sales, general contracting and management. The Building Construction Department was established to supply graduates who, with the architect and engineer, help to coordinate all building projects. The course includes building design and a survey of history and specializes in the technical studies of structures, materials, finance and management problems. The degree, Bachelor of Science in Building Construction, is awarded upon the completion of four years of study.

Two options available to the student are management and construction. The management option prepares the student to enter one of the fastest growing professions: construction manager. The management of the building construction — from land acquisition, planning and financing to design, construction and

management – is being written into more and more government and private construction contracts. The construction option prepares the student for the more traditional role of the professional contractor who, with application of value engineering achieves the production of a building facility according to the architect's and engineer's design. This course prepares the student for a wide variety of building facilities or systems, or to specialize in a particular area of materials production or construction inspection.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Arch. 1201-2-3	Architectural History	3-0-3	3-0-3	3-0-3
B.C. 1851	Building Construction Seminar	.....	.....	0-3-1
Chem. 1101-2	General Chemistry	4-3-5	4-3-5	.....
Geol. 2500	Physical Geology	.....	.....	3-3-4
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives ²	Physical Education	0-4-1	0-4-1	0-4-1
Electives ¹		3-0-3	3-0-3	3-0-3
Totals		15-7-17	15-7-17	14-10-17

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Arch. 2301-2-3	Building Anatomy	3-0-3	3-0-3	3-0-3
B.C. 2001-2-3	Design of Building Systems	1-12-5	1-12-5	1-12-5
Econ. 2000	Microeconomics	3-0-3	.....	.....
E.S.M. 3701-2	Statics, Strength of Materials	.....	3-0-3	3-0-3
Phys. 2111-2-3	Elementary Physics	4-0-4	4-0-4	4-0-4
Electives ¹		3-0-3	3-0-3	3-0-3
Totals		14-12-18	14-12-18	14-12-18

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Arch. 3321-2-3	Structures and Materials	4-3-5	4-3-5	4-3-5
B.C. 3301-2-3	Construction Practice	3-0-3	3-0-3	3-0-3
Mgt. 3260	Law I	3-0-3	.....	.....
Mgt. 3700	Analysis of Financial Data	.....	3-3-4	.....
I.Sy.E. 4035	Project Management Systems Design	.....	.....	2-3-3
Electives ¹		6-0-6	5-0-5	6-0-6
	Totals	16-3-17	15-6-17	15-6-17

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Arch. 3421-41	Facilities Planning, Building Economics	.....	3-0-3	3-0-3
B.C. 3441	Building Production	3-0-3	.....	.....
Electives ¹		13-0-13	13-0-13	13-0-13
	Totals	16-0-16	16-0-16	16-0-16

¹A total of 74 hours of electives are included in the curriculum in building construction and, with the advice of faculty counselors, they should be programmed to include the categories below. These categories will satisfy the core curriculum requirements of the College of Engineering in the humanities and social sciences, additional professional requirements of the curriculum and will allow a degree of latitude for the student to pursue individual interests.

Humanities: nine credit hours are to be devoted to English literature courses or to appropriate modern language courses at the 3000 level or above. Note that the architectural history sequence will satisfy the remaining humanities requirements.

Social Sciences: 18 credit hours, including at least one course in each of sociology, political science and psychology.

General Electives: Of the remaining 47 hours, 21 hours must be selected from the list of approved professional electives in the option chosen by the student. Military training is an optional requirement of the institute, but in case basic ROTC and advanced military are elected, no more than 15 credit hours of general electives may be used for this purpose or will be credited toward the requirements for a degree.

²See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women.

Industrial Design

Industrial design is a broad field of study concerned with the form, function and appearance of the diverse products manufactured for home, industrial and recreational uses. The designer's role is a complex one. He must have the ability to define problems, to conceptualize and implement solutions by utilizing a vast range of materials, industrial machines and modern marketing techniques. Most important is the satisfaction of human needs for convenience, safety and aesthetic values. The curriculum in industrial design prepares the student through basic professional studies and general education to receive the degree Bachelor of Industrial Design on the completion of four years of study.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Arch. 1001-2-3	Design Fundamentals	1-12-5	1-12-5	1-12-5
I.D. 1261-2-3	History of Design	3-0-3	3-0-3	3-0-3
Math. 1307-8-9	Mathematics	5-0-5	5-0-5	5-0-5
Electives ³	Physical Education	0-4-1	0-4-1	0-4-1
Electives ¹		3-0-3	3-0-3	3-0-3
	Totals	12-16-17	12-16-17	12-16-17

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
I.D. 2001-2-3	Industrial Design	1-12-5	1-12-5	1-12-5
I.D. 2301-2-3	Materials and Process Design	1-3-2	1-3-2	1-3-2
Phys. 2111-2-3	Elementary Physics	4-0-4	4-0-4	4-0-4
Econ. 2003	Microeconomics	3-0-3	.....	.....
E.S.M. 3701	Statics	.....	.....	.....
Electives ¹		.....	.....	3-0-3
Electives ²		3-0-3	3-0-3	3-0-3
	Totals	12-15-17	12-15-17	12-15-17

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
I.D. 3001-2-3	Industrial Design	1-12-5	1-12-5	1-12-5
I.D. 3301-2-3	Materials and Process Design	1-3-2	1-3-2	1-3-2
Psy. 3303	Psychology	3-0-3	.....	.....
I.Sy.E. 4048	Systems Design	.....	.....	3-0-3
Electives ¹		.....	3-0-3	.....
Electives ²		7-0-7	7-0-7	7-0-7
Totals		12-15-17	12-15-17	12-15-17

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
I.D. 4001-2-3	Industrial Design	1-21-8	1-21-8	1-21-8
Mgt. 3300	Marketing	3-0-3	.....	.....
I.Sy.E. 3010	Man-Machine Systems	.....	.....	3-0-3
Electives ¹		.....	3-0-3	.....
Electives ²		6-0-6	6-0-6	6-0-6
Totals		10-21-17	10-21-17	10-21-17

¹Electives: nine credit hours of technical electives to be chosen from the departmental list.

²Electives: A total of 57 additional credit hours of electives are included in the curriculum for industrial design and, with the advice of faculty counselors, they should be programmed to include the categories below. These categories will satisfy the core curriculum requirements of the College of Engineering in the humanities and social sciences, additional professional requirements of industrial design and will allow a degree of latitude for the student to pursue individual interests.

Humanities: nine credit hours are to be devoted to English literature courses or to appropriate modern language courses at the 3000 level or above. Note that the history of design sequence will satisfy the remaining nine credit hours of humanities requirements.

Social Sciences: 18 credit hours including at least one course each in sociology, political science and psychology.

General Electives: 30 credit hours may be structured to best further the student's professional goals, but must include at least six credit hours in visual communica-

tion studio courses. Military training is an optional requirement of the institute, but, in case basic ROTC and advanced military are elected, no more than 15 credit hours of general electives may be used for this purpose or will be credited toward the requirements for a degree.

*See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women.

Graduate Program in City Planning

Three types of degree programs are available for students interested in the fields of urban and regional planning: the two-year professional Master of City Planning degree (recognized by the American Institute of Planners for membership purposes), the joint Master of City Planning and Master of Science in a related field and the undesignated Master of Science degree (not recognized by the American Institute of Planners but considered a degree in a related field for membership purposes).

Master of City Planning Degree

The two-year curriculum requires, for most students, five quarters of course work, one quarter for a thesis and one quarter as an intern in the office of an approved planning agency. Required courses are: C.P. 4401, 6000, 6010, 6020, 6030, 6060, 6090, 6100, 6110, 6120, 6140, 6260, 6270, 6350, 6360, C.E. 6703, Pol. 6255, Soc. 6375 and electives – nine credit hours.

With the approval of his faculty adviser, a student may substitute 25 credit hours in a field of specialization instead of the thesis provided he has appropriate undergraduate preparation. At least six credit hours must be in independent study.

Joint Degrees

Joint degrees are offered in city planning and transportation engineering (M.S. Civil Engineering), urban design (Master of Architecture) and civic design (Master of Landscape Architecture, University of Georgia).

Master of Science (undesignated) Degree

Interdisciplinary programs are available for those students who desire an in-depth understanding of a particular segment of the field of urban and regional planning. Acceptance into these programs is limited to those applicants whose training or experience is in a discipline or professional field clearly related to urban and regional planning.

School of Ceramic Engineering

(Established 1924)

Director—Joseph L. Pentecost; *Professors*—Lane Mitchell (Emeritus), A. T. Chapman, Willis E. Moody; *Associate Professor*—W. C. Hansard (Emeritus), James F. Benzel; *Assistant Professor*—Joe K. Cochran, Jr.; *Instructor*—Stanley Byers; *Special Lecturers*—R. A. Young and Robert Lane Mitchell.

General Information

The ceramic industry produces over \$10 billion worth of products annually in the United States. These products range from brick, tile, glass, portland cement and dinnerware to high-temperature refractories for furnace linings, abrasives and sophisticated electronic components. These traditional products create a continuing demand for personnel trained in this field and new products which are continuously developing open new opportunities. Over the past 20 years these new products have included rocket nozzles and jet engine components, electronic circuitry for computers and fiberglass products for nose cones and missiles. Current developments include automotive exhaust catalyst supports and other pollution control devices, new lighting techniques and electro-optical materials.

The raw materials for ceramic products are the most plentiful minerals in the earth's crust. Consequently, many are relatively cheap and result in durable, economical, temperature-resistant materials that are in continuous demand for innovative design.

Ceramic engineering applies sound scientific and engineering principles to solve manufacturing problems in the industry. Frequently these problems are complex and challenging for chemical and physical reactions are occurring at high temperatures. Measurements are difficult, and cost constraints for economical production are always present.

The School of Ceramic Engineering offers a four-year curriculum leading to the bachelor's degree and graduate work leading to Master of Science and Doctor of Philosophy degrees in ceramic engineering. The undergraduate curriculum is designed to prepare the degree candidate for a position in the ceramic industry or for graduate work. Courses are also offered to non-majors to introduce them to ceramic materials and processes or to develop specific skills and knowledge in the application of ceramic materials.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1111-2	General Chemistry	4-3-5	4-3-5	.....
Chem. 2113	Chemical Principles	.....	.....	3-3-4
Elective	E.Gr. 1170, Introduction to Visual Communication and Engineering Design I (2-3-3) and one of the engineering electives ¹	X-X-3	X-X-3	.....
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives ³	Physical Education	0-4-1	0-4-1	0-4-1
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives ²	Free	2-0-2	2-0-2	2-0-2
Totals		16-10-19	16-10-19	13-7-15

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Cer.E. 3001	Ceramic Data Handling	.....	.....	2-3-3
Cer.E. 3002	Properties of Engineering Materials	.....	.....	2-3-3
E.S.M. 2201	Statics	3-0-3	.....	.....
E.S.M. 3201	Applied Mechanics	.....	3-0-3	.....
Math. 2307	Calculus IV	5-0-5	.....	.....
Math. 2308	Calculus and Linear Algebra	.....	5-0-5	.....
Phys. 2121-2-3	Physics	4-3-5	4-3-5	4-3-5
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	6-0-6
Electives ²	Free	.....	.....	2-0-2
Totals		15-3-16	15-3-16	14-9-17

Junior year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Cer.E. 3003	Ceramic Processing I	3-3-4	.....	.....
Cer.E. 3004	Ceramic Processing II	.....	2-3-3	.....
Cer.E. 3005	Phase Equilibria for Ceramists	3-0-3	.....	.....
Cer.E. 3006	Physical Ceramics I	3-0-3	.....	.....
Cer.E. 3007	High Temperature Analysis	.....	2-3-3	.....
Cer.E. 3008	Glass Technology I	.....	2-3-3	.....
Cer.E. 4018	Drying and Psychrometry	.....	.....	2-0-2
Cer.E. 4052	Inorganic Phase Ana- lysis and Identifica- tion	.....	.....	3-3-4
Chem. 3412	Physical Chemistry	.....	3-0-3	.....
Chem. 3413	Physical Chemistry	.....	.....	3-0-3
Chem. 3481	Physical Chemistry Lab	.....	.....	0-6-2
Geol. 2500	General Geology	3-3-4	.....	.....
E.S.M. 3301	Mechanics of De- formable Bodies	.....	.....	5-0-5
Electives	Humanities/Social Science/Modern Language	.....	3-0-3	3-0-3
Electives	Free	2-0-2	3-0-3	.....
Totals		14-6-16	15-9-18	16-9-19

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Cer.E. 4002	Refractories and Com- bustion	3-3-4	.....	.....
Cer.E. 4003	Physical Ceramics II	.....	2-3-3	.....
Cer.E. 4004	High Temperature Thermodynamics	.....	2-0-2	.....

Senior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Cer.E. 4005	Glass Technology II	2-3-3	.....	.....
Cer.E. 4010-1-2	Technical Management and Design Problems I, II, III	1-3-2	0-6-2	0-3-1
Cer.E. 4015-6-7	Independent Research Project I, II, III	1-0-1	1-3-2	0-6-2
I.Sy.E. 4725	Engineering Economy	.....	.....	3-0-3
Elective	Either E.E. 3700, Elements of Electrical Circuits and Instruments (3-0-3) or E.E. 3725, Electric Circuits and Fields (2-3-3)	.....	.....	X-X-3
Elective	Metallurgy	3-0-3	.....	.....
Elective	Humanities/Social Science/Modern Language	3-0-3	6-0-6	.....
Elective	Free	.....	3-0-3	6-0-6
	Totals	13-9-16	14-12-18	11-12-15

¹See College of Engineering section "Curricula and Degrees" for engineering electives.

²These free elective courses may be taken at any time during a student's course of study.

³See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women.

School of Chemical Engineering

(Established in 1901)

Director—G. L. Bridger; *Chemical Engineering Faculty: Associate Director and Regents' Professor*—Clyde Orr, Jr.; *Regents' Professor*—W. T. Ziegler; *Professors*—Frederick Bellinger (Emeritus), George A. Fowles (Adjunct), Charles W. Gorton, Homer V. Grubb, H. Clay Lewis, Henderson C. Ward, Paul Weber (Emeritus); *Associate Professors*—John H. Burson, III., Michael J. Matteson, John D. Muzzy, Jude T. Sommerfeld; *Assistant*

Professors—William R. Ernst, Anthony L. Hines, George R. Lightsey, Joseph J. Smrekar. **Metallurgy Faculty: Associate Director and Professor**—Robert F. Hochman; **Professors**—Niels N. Engel (Emeritus), Edgar A. Starke, Jr., E. E. Underwood; **Associate Professors**—Helen Grenga, Bruce G. LeFevre, Pieter Muije, Stephen Spooner.

General Information

Chemical engineers perform essential functions in industries that convert raw materials into useful finished products by means of chemical and physical processes. Almost every major manufacturing industry employs chemical engineers in research, development, design, production, sales, consulting and management positions. Substantial numbers of chemical engineers are employed in petroleum, petrochemical, pulp and paper, plastics, metallurgical, fiber, fertilizer, nuclear energy, space, rubber, food, photographic, heavy and fine chemical, mineral, pharmaceutical and dye industries. Environmental and pollution control activities require an increasing number of chemical engineers.

The School of Chemical Engineering offers programs leading to the degrees Bachelor of Chemical Engineering, Master of Science in Chemical Engineering, Master of Science in Metallurgy and Doctor of Philosophy. The doctoral program may be in either chemical engineering or metallurgy. Interdisciplinary programs and undesignated degrees are also available.

The following curriculum leads to the degree of Bachelor of Chemical Engineering and is designed to train students both for positions immediately upon graduation or for additional study leading to the master's and doctoral degrees.

By judicious choice of free and technical electives, a student may include in his curriculum an area of concentration in which he may have a special interest. Typical areas of concentration are chemical metallurgy, physical metallurgy, plastics engineering, biomedical engineering, environmental engineering, simulation science and instrument technology. Detailed descriptions for each of these areas are available from the Ch.E. office.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Ch.E. 1101	Introduction to Chemical Engineering	1-0-1	.....	.....

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.Gr. 1170 Elective ⁷	Visual Communication Freshman Engineer- ing Electives	.....	2-3-3	..... X-X-3
Chem. ¹ 1111-2	General Chemistry	4-3-5	4-3-5	.....
Chem. 2113	Chemical Principles	.....	.....	3-3-4
Engl. ² 1001-2-3	Introduction to Literature	3-0-3	3-0-3	3-0-3
Math. 1307-8-9	Calculus	5-0-5	5-0-5	5-0-5
Electives ⁸	Physical Education	0-4-1	0-4-1	0-4-1
Electives ³		2-0-2	2-0-2	2-0-2
	Totals	15-7-17	16-10-19	15-10-18

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Ch.E. 2207-8	Chemical Process Principles	3-0-3	3-0-3	.....
Ch.E. 2209	Computers in Chemical Engineering	.....	.....	2-3-3
Ch.E. 3304	Transport Phenomena	.....	.....	3-3-4
Math. 2307-8	Calculus	5-0-5	5-0-5	.....
Phys. 2121-2-3	Physics	4-3-5	4-3-5	4-3-5
Electives ⁴	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
	Totals	15-3-16	15-3-16	12-9-15

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Ch.E. 3305	Transport Phenomena	3-3-4	.....	.....
Ch.E. 3306-15	Unit Operations	.....	3-0-3	3-3-4
Chem. 3311-2-3	Organic Chemistry	3-0-3	3-0-3	3-0-3

Junior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 3381	Organic Chemistry Lab	0-6-2	.....	.....
Chem. 3411-2-3	Physical Chemistry	3-0-3	3-0-3	3-0-3
Chem. 3481	Physical Chemistry Lab	.....	.....	0-6-2
E.S.M. 2201	Statics	3-0-3	.....	.....
E.E. 3700	Electrical Circuits and Fields	.....	.....	3-0-3
E.E. 3740	Electrical Engineering Laboratory	.....	.....	0-3-1
Met. 3301	Engineering Materials	.....	4-3-5	.....
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives	Free	.....	3-0-3	.....
	Totals	15-9-18	19-3-20	15-12-19

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Ch.E. 4438	Chemical Engineering Thermodynamics	4-0-4	.....	.....
Ch.E. 4415	Reactor Design	.....	3-0-3	.....
Ch.E. 4413	Unit Operations	3-3-4	.....	.....
Ch.E. 3339	Chemical Engineering Literature	1-0-1	.....	.....
Ch.E. 4431	Chemical Engineering Economics	3-0-3	.....	.....
Ch.E. 4432	Process and Equipment Design	.....	2-3-3	.....
Ch.E. 4434	Plant Design	.....	.....	1-6-3
Ch.E. 4416	Process Control	.....	3-3-4	.....
Electives ⁵	Technical	3-0-3	.....	6-0-6
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives	Free	.....	3-0-3	3-0-3
	Totals	17-3-18	14-6-16	13-6-15

¹Advanced level chemistry for chemical engineering majors. However, Chem. 1101-1102 will be accepted for students transferring to chemical engineering from other curricula.

²Other humanities courses listed in the undergraduate section will be accepted for students transferring to chemical engineering from other curricula.

³These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, then ROTC should be scheduled beginning the first quarter the student is enrolled.

⁴Language is recommended for students considering graduate work.

⁵From approved list.

The chemical engineering curriculum contains a total of 51 hours of electives, comprising 15 hours of free electives, nine hours of technical electives and 27 hours of electives in humanities, social sciences and modern languages. Students electing to take ROTC must use six hours of free electives for basic ROTC and nine hours of free electives for advanced ROTC. The 27 hours of electives in humanities, social sciences and modern languages must be chosen from the list of courses in the undergraduate section in accordance with the distribution there specified. The technical electives must be chosen from the list of approved technical electives available from the Ch.E. office.

⁶See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women.

⁷See College of Engineering section "Curricula and Degrees" for engineering electives.

School of Civil Engineering

(Established In 1896)

Director—William M. Sangster; *Assistant Director*—Paul H. Sanders; *Professors Emeritus*—John O. Eichler, James H. Lucas, Radnor J. Paquette; *Regents' Professors*—Paul G. Mayer, George F. Sowers; *Professors*—Marion R. Carstens, Austin B. Caseman, Donald O. Covault, R. Kenneth Jacobs (in charge of Engineering Graphics program), Richard King, Charles S. Martin, Frederick G. Pohland, Frederick W. Schutz, Jr., Thomas E. Stelson, Robert E. Stiemke, Paul H. Wright; *Associate Professors*—Richard D. Barksdale, William F. Brumund, Leroy Z. Emkin, Russell G. Hicks, Alfred W. Hoadley, John D. Hutcheson, Billy H. Kornegay, Billy B. Mazanti, Peter S. Parsonson, Dale C. Perry, George M. Slaughter, H. William Streitman, Calvin W. Tooles, James R. Wallace, Earl M. Wheby, Ira E. Wilks; *Assistant Professors*—Richard R. Avent, Geoffrey N. Berlin, Michael S. Bronzini, Russell H. Brown, Carl O. A. Charles, Daniel W. Halpin, James H. Hardcastle, Alan M. Lumb, Mark A. McClanahan.

General Information

The School of Civil Engineering offers courses in civil engineering and engineering graphics and programs leading to the degrees

Bachelor of Civil Engineering, Bachelor of Science (undesignated), Master of Science in Civil Engineering, Master of Science in Sanitary Engineering, Master of Science (undesignated) and Doctor of Philosophy. Also offered is a joint two-year program leading to the simultaneous awarding of the degrees Master of Science in Civil Engineering or Master of Science (undesignated, major in transportation engineering) and Master of City Planning.

Program in Engineering Graphics

Engineering design graphics is a multi-faceted descriptive title uniting creative design with its avenue of expression, graphics.

While creativity is an art rather than a science, it is an art that can be learned and applied. When applied to engineering design it becomes an orderly, step-by-step, structured, decision-making process, actually more related to inventiveness than to research. Success in this relatively new addition to engineering curricula is predicated upon continued practice, therefore this iterative growth process is prescribed early in the student's career.

The goals of this program are to kindle in the student an awareness of the professional role he is ultimately to play in the area of design, to afford him live opportunities to participate creatively and to provide instruction in the most flawless communication medium known to man.

Bachelor of Civil Engineering

The four-year curriculum leading to the degree Bachelor of Civil Engineering is designed to enable the graduate to enter professional practice as an engineer or to continue his studies in programs leading to advanced degrees in the following broad fields of specialization: construction, environmental engineering, fluid mechanics, hydraulics, hydrology, sanitary engineering, soil mechanics, structures, surveying, transportation and water resources planning and management. The graduate of the B.C.E. curriculum may function in the areas of planning and design, construction, research and development, operations and maintenance. The curriculum leading to the degree Bachelor of Civil Engineering has been continuously accredited by the Engineers' Council for Professional Development since the inauguration of its accrediting program during the period 1936-38. Graduates of the B.C.E. curriculum are eligible to seek licensing as registered professional engineers.

The course requirements of the Bachelor of Civil Engineering degree are tabulated here. Many of the courses need not be taken

during the quarter indicated, but prerequisites must be satisfied.

In addition to campus-wide academic requirements for graduation with a bachelor's degree, the following are also required for the B.C.E. degree.

- (a) The scholastic average shall be a minimum of 2.0 for those quarters during which the last 54 hours toward the degree are taken.
- (b) The number of quality points earned in civil engineering courses taken toward the degree must be at least twice the number of credit hours in those courses.
- (c) No more than twelve hours of free electives may be taken on a pass/fail basis. No other courses may be taken on a pass/fail basis.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1101-2	Inorganic Chemistry	4-3-5	4-3-5	.....
Econ. 2000	Economics	.....	.....	3-0-3
E.Gr. 1170	Visual Communication	2-3-3	.....	.....
Elective ¹	Freshman Engineering Elective	.....	X-X-3	.....
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Phys. 2121	Physics	.....	.....	4-3-5
Electives ⁷	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives ²	Free	1-0-1	1-0-1	1-0-1
Electives ³	Physical Education	0-4-1	0-4-1	0-4-1
	Totals	15-10-18	15-10-18	16-7-18

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.S.M. 2201	Statics	3-0-3	.....	.....
E.S.M. 3201	Dynamics	.....	3-0-3	.....
Math. 2307	Calculus IV	5-0-5	.....	.....
Math. 2308	Calculus and Linear Algebra	.....	5-0-5	.....

Sophomore Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Elective ⁶	Mathematics	.....	.....	5-0-5
Phys. 2122-3	Physics	4-3-5	4-3-5	.....
E.S.M. 3301	Mechanics of De- formable Bodies	.....	.....	5-0-5
C.E. 2254	Plane Surveying	.....	.....	3-3-4
Electives ⁷	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives ²	Free	1-0-1	1-0-1	1-0-1
	Totals	16-3-17	16-3-17	17-3-18

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
C.E. 3254	Surveying	.....	3-3-4	.....
C.E. 2502	Digital Computers	1-3-2	.....	.....
C.E. 3309	Materials of Construction	3-3-4	.....	.....
C.E. 3216	Structural Analysis I	5-3-6	.....	.....
C.E. 3053-4	Fluid Mechanics I, II	.....	3-0-3	3-3-4
Geol. 2500	Physical Geology	.....	3-3-4	.....
Elective	Either I.Sy.E. 4725, Engineering Eco- nomy or I.Sy.E. 4726, Engineering Economic Analysis in the Public Sector	.....	.....	3-0-3
M.E. 3720	Thermodynamics	.....	.....	4-0-4
C.E. 4204	Metal Structural Components	.....	3-3-4	.....
Electives ⁷	Humanities/Social Science/Modern Language	3-0-3	.....	3-0-3
Electives ⁴	Free	3-0-3	.....	3-0-3
	Totals	15-9-18	12-9-15	16-3-17

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
C.E. 3061	Fluid Mechanics Laboratory	0-3-1	.....	.....
C.E. 4214	Concrete Structural Components	3-3-4	.....	.....
C.E. 4304	Transportation Engineering I	.....	3-3-4	.....
C.E. 4103-13	Sanitary Engineering I, II	3-0-3	3-0-3	.....
C.E. 4353	Hydrology	3-0-3	.....	.....
C.E. 4154	Behavior of Soil and Rock	.....	3-3-4	.....
E.E. 3740	Electrical Instrumentation Laboratory	.....	.....	0-3-1
E.E. 3700	Elements of Electric Circuits and Instruments	.....	.....	3-0-3
Elective	Either Mgt. 3260, Law I or I.Sy.E. 4090, Legal and Ethical Phases of Engineering	.....	.....	3-0-3
Electives ⁷	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives ⁵	C.E.	3-0-3	3-0-3	6-0-6
Electives ⁴	Free	.....	.....	3-0-3
Totals		15-6-17	15-6-17	18-3-19

¹See College of Engineering section "Curricula and Degrees" for engineering electives.

²These free elective courses may be taken at any time during a student's course of study.

³See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁴See Physical Education section of "Curricula and Degrees." Nine hours of free electives at the 3000 level or higher must be taken if advanced ROTC is not taken.

⁵C.E. electives. Each C.E. senior must choose four of the following courses: C.E. 4003, 4053, 4123, 4133, 4143, 4163, 4213, 4223, 4233, 4253, 4263, 4273, 4283, 4313, 4363, 4373, 4383 or 4774.

*Mathematics elective. Either Math. 2309, 3308 or 3215.

*See "Information for Undergraduate Students" section of this catalog for humanities, social science and modern language requirements.

Master of Science

Three degrees in this category are awarded by the School of Civil Engineering: Master of Science in Civil Engineering, Master of Science in Sanitary Engineering and the undesignated Master of Science. Common requirements for these degrees, in addition to those specified in "Information for Graduate Students," are listed below.

1. A minimum of 50 hours of course work is required, of which none was used to satisfy requirements for a previous degree, as approved by the student's adviser and the director.
2. Up to 15 of the 50 hours may be in 3000-4000 level courses. Courses required for the B.C.E. degree may not be used to satisfy this requirement; other 3000-4000 level courses may be used subject to the approval of the adviser and director.
3. Up to six of the 50 hours may be taken on a pass/fail basis with the approval of the adviser and director.
4. Each M.S. student is required to either (a) write an M.S. thesis and schedule at least 17 hours of C.E. 7000, or (b) write an M.S. special research problem and schedule between six and 12 hours of C.E. 8756. No more than 17 hours of C.E. 7000, or no more than 12 hours of C.E. 8756, may be counted as part of the 50 hours required for the M.S. degree.
5. Students electing to write an M.S. thesis must take at least 18 hours of course work in their major field. Students electing to write an M.S. special research problem must take at least 27 hours of course work (including C.E. 8756) in their major field.

The Master of Science in Civil Engineering degree is awarded only to students who have previously earned the B.C.E. degree or equivalent. The Master of Science in Sanitary Engineering degree is awarded only to those students who have previously earned the B.C.E. degree or who have earned an accredited bachelor's degree in engineering and have taken those undergraduate courses (for no credit toward the M.S.) required by their adviser and the director. The undesignated Master of Science degree is awarded to students not meeting the above requirements, but who have satisfied all prerequisites for the courses in their M.S. program.

A wide range of M.S. programs is available in such fields as construction, environmental engineering, fluid mechanics, hydraulics, hydrology, sanitary engineering, soil mechanics, structures, transportation and water resources planning and management. Latitude in the selection of courses in an M.S. program is encouraged, provided that the resulting program leads to a definable goal.

The degrees Master of Science in Civil Engineering and Master of Science in Sanitary Engineering are accredited by the Engineers' Council for Professional Development.

Doctor of Philosophy

The Ph.D. is the highest degree awarded and as such requires the highest level of proficiency and achievement, both in knowledge and in the performance of research presented in a written dissertation. While there are no specific course requirements, most doctoral students spend approximately two years in course work beyond the bachelor's degree before beginning their research activities.

School of Electrical Engineering

(Established in 1896)

Director and Professor—Demetrius T. Paris; *Regents' Professors*—John W. Hooper, Kendall L. Su; *Professors*—Aubrey M. Bush, Daniel C. Fielder, David L. Finn, Joseph L. Hammond, Jr., Robert D. Hayes, F. Kenneth Hurd, Howard L. McKinley (Emeritus), Frank O. Nottingham, Jr. (Emeritus), John B. Peatman, George P. Rodrigue, Albert P. Sheppard, Jr., Charles R. Vail, Roger P. Webb (Georgia Power Chair), Edward R. Weston (Emeritus), Thomas M. White, Jr.; *Associate Professors*—Cecil O. Alford, Joseph A. Connelly, Ronal W. Larson, Mohamed F. Moad, Ray H. Pettit, Dale C. Ray, Jay H. Schlag, Robert F. Thompson (Adjunct), John M. Wallace, Jr.; *Assistant Professors*—Thomas P. Barnwell III, James E. Brown III, William R. Callen, Jr., Chee-Yee Chong, Atif S. Debs, Louis J. DeFelice, Robert K. Feeney, Thomas K. Gaylord, Patrick R. Hirschler, Edward B. Joy, Edward W. Kamen, W. Marshall Leach, Jr., Barry M. Leiner, John D. Norgard, H. Neal Nunnally, William T. Rhodes, William E. Sayle II, Moiez A. Tapia, Edward B. Wagstaff, M. Edward Womble; *Instructors*—Audrey R. Carlson, Gene K. Huddleston; *Lecturers*—Donald G. Bodnar, Allen H. Cherin, Charles E. Ryan, Jr., Nicholas A. Strakhov.

General Information

Electrical engineers have pioneered the fields of electronics, computers, control, power and communication. Their work is vital in almost every sector of society. The tremendous effect of electrical engineering on society can be explained by the fact that electrical energy is the only known form of energy which can be transmitted efficiently under controlled conditions, even through a vacuum, and by means of which intelligence can be processed and transferred effectively even over extremely long distances.

The School of Electrical Engineering seeks to attract students who possess a verbal and written command of the English language, who exhibit logical thinking, creativity, curiosity, imagination, persistence, patience and who have proved their academic excellence in mathematics, chemistry and physics.

At the undergraduate level, the basic required program of instruction in fundamental theory and laboratory practice is balanced by a broad range of electives. Many electives have been organized into tracks such as bioelectronics, computer engineering, energy engineering, instrumentation and controls and urban engineering.

The student may also design a program, with the counsel and guidance of faculty adviser, around other interests.

The graduate programs leading to the master's and doctoral degrees are designed to provide a broad education covering more than one specialty, followed by in-depth studies of major and minor interest areas. The doctoral program requires, in addition, concentration in a single specialty or in a group of closely related specialties.

Graduate programs include bioelectronics, communications, computer systems, control systems, electric power, optical engineering, electromagnetics, instrumentation, network and system theory and physical electronics. Multidisciplinary programs in areas such as computer engineering and acoustic engineering are offered jointly with other engineering schools on campus. Full programs of courses are offered during the summer quarter, making it possible for part-time students to continue an uninterrupted program of study throughout the year.

Housed in one of the finest facilities in the world, the school maintains a vigorous program of student-centered research conducted in well equipped laboratories.

Additional information about the programs may be obtained from the school's *Student Handbook* or *Graduate Brochure*, available upon request, or by calling the school at (404) 894-2900. These sources of information must be consulted with respect to special rules and degree requirements by every student enrolled.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ¹		.....	.....	3-0-3
Electives ²	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective	E.Gr. 1170, Introduction to Visual Communication and Engineering Design I (2-3-3) and one of the Engineering Electives ⁵	X-X-3	X-X-3	.....
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Phys. 2121	Particle Dynamics	.....	.....	4-3-5
Chem. 1101-2	General Chemistry	4-3-5	4-3-5	.....
Electives ³	Physical Education	0-4-1	0-4-1	0-4-1
	Totals	14-10-17	14-10-17	15-7-17

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ¹		3-0-3	.....	.....
Electives ²	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
E.S.M. 2201	Statics	3-0-3	.....	.....
E.S.M. 3201	Dynamics I	.....	.....	3-0-3
Math. 2307	Calculus IV	5-0-5	.....	.....
Math. 2308	Calculus and Linear Algebra	.....	5-0-5	.....
Math. 3308	Ordinary Differential Equations	.....	.....	5-0-5
Phys. 2122	Electromagnetism	4-3-5	.....	.....
Phys. 2123	Optics and Modern Physics	.....	4-3-5	.....

Sophomore Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.E. ⁴ 3200-50	Elements of Electrical Engineering	.....	3-0-3	3-0-3
E.E. 3400	Instrumentation Laboratory	.....	.....	1-3-2
	Totals	18-3-19	15-3-16	15-3-16

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ¹		4-0-4	4-0-4	4-0-4
Electives ²	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
E.E. 3300-10-20	Electromagnetics	3-0-3	3-0-3	3-0-3
E.E. 3210-20	Circuits and Systems	3-0-3	3-0-3	.....
E.E. 3260	Engineering Electronics	3-0-3	.....	.....
E.E. 3270	Nonlinear Devices and Circuits	.....	3-0-3	.....
E.E. 3330	Electromechanical Systems and Energy Conversion	.....	.....	3-0-3
E.E. 3340	Random Signals and Noise	.....	.....	3-0-3
E.E. 3410-20-30	Junior E.E. Laboratory I, II, III	0-3-1	0-3-1	0-3-1
	Totals	16-3-17	16-3-17	16-3-17

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ¹		10-0-10	13-0-13	13-0-13
Electives ²	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3

Senior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.E. 4350	Materials Science	3-0-3	.....	.....
E.E. 4410-20	Senior E.E. Laboratory			
	I, II	0-3-1	0-3-1	.....
E.E. 4430	Project Laboratory	.....	.....	0-3-1
	Totals	16-3-17	16-3-17	16-3-17

¹Electives: The electrical engineering curriculum contains 57 hours of electives, in addition to 36 hours of specified humanities/social science/modern language electives. The 57 hours of electives must include a minimum of three hours of freshman engineering electives, 12 hours of technical electives, subject to school approval, outside the major field, including one of the following five thermodynamics options: (1) M.E. 3720 (2) M.E. 3726 (3) M.E. 3322 and M.E. 3323 (4) Physics 3141 (5) a course or courses approved by the School of Electrical Engineering and 21 hours of electives in electrical engineering, subject to school approval. Thus, 21 credit hours of entirely free electives are included in the curriculum. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit in the program.

²Three credit hours each of literature, history and political science must be included. One year of freshman English is strongly recommended. Additional humanities/social science/modern language electives and their required distribution are given in "Information for Undergraduate Students."

³See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women.

⁴It is expected that each student, through independent study, attendance at seminars or formal courses, will acquire the ability to program simple problems on one of the digital computers available on campus prior to enrollment in E.E. 3200.

⁵See College of Engineering section "Curricula and Degrees" for engineering electives.

School of Engineering Science and Mechanics

(Established 1959)

Director—Milton E. Raville; *Regents' Professor Emeritus*—Phil Blasier Narmore; *Regents' Professor*—Andrew W. Marris; *Professors Emeritus*—Bryan L. Brown, Francis M. Hill, William B. Johns, Jr., Charles E. Stoneking; *Professors*—William J. Lnenicka, George J. Simitzes, James T. S. Wang, Gerald A. Wempner; *Associate Professor Emeritus*—Francis C. Bragg; *Associate Professors*—Jerry M. Anderson, James H. Armstrong, Satya N. Atluri, Michael C. Bernard, Wilton W. King, David J. McGill, George M. Rentzepis, Robert W. Shreeves, Charles E. S. Ueng; *Assistant Professors*—James A. Aberson, Donald G. Berghaus,

Hyland Y. L. Chen, John C. Clark, Stephen L. Passman, Raymond P. Vito.

General Information

The School of Engineering Science and Mechanics administers the undergraduate curriculum leading to the degree Bachelor of Engineering Science and graduate programs leading to the degrees of Master of Science, Master of Science in Engineering Science and Mechanics and Doctor of Philosophy.

The primary objective of the undergraduate curriculum is to prepare students for careers in engineering and related fields emphasizing the fundamental principles and techniques of mathematics and the engineering sciences – solid mechanics, fluid mechanics, materials science, electrical sciences, heat transfer and thermodynamics. The curriculum, totaling 205 credit hours, provides for 83 hours of elective credit, including 23 hours of free electives, 27 hours of technical electives and 33 hours of humanities/social science/modern language electives. The engineering science curriculum is considered particularly well suited for the above average student whose specific goals within the general framework of engineering and the physical sciences have not yet been formulated.

Elective options provide in-depth study in interdisciplinary, technically-related areas, as well as preparation for professional schools of business, law and medicine. Thus, the engineering science graduate has a wide choice of specialized areas that can provide a foundation for starting his career or for further study.

Graduate study and research in the School of Engineering Science and Mechanics includes work in modern continuum mechanics, stress analysis, stability, structures, dynamics, vibrations, space mechanics, fluid mechanics, biomechanics, acoustics, wave propagation, applied stochastic processes, optimization techniques, materials science and experimental stress analysis. A wide variety of related graduate courses is also available to the E.S.M. graduate student in the other schools of the institute. Flexibility and interdisciplinary interests are encouraged in the planning of individual programs of study.

The faculty of the School of Engineering Science and Mechanics holds degrees in most of the recognized branches of engineering, as well as mathematics and physics. Housed in two buildings, E.S.M. has excellent classroom, office and shop facilities and modern, newly-equipped laboratories. Various grants, assistantships and fellowships are available to students of outstanding merit.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ¹	Engineering	X-X-3	.....	.....
Chem. 1101-2	Inorganic Chemistry	4-3-5	4-3-5	.....
E.Gr. 1170	Visual Communication and Engineering Design I	.....	2-3-3	.....
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Phys. 2121	Physics	.....	.....	4-3-5
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective ²	Free	.....	.....	3-0-3
Electives ⁶	Physical Education	0-4-1	0-4-1	0-4-1
	Totals	14-10-17	14-10-17	15-7-17

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.S.M. 2101-2	Engineering Design I, II	0-3-1	0-6-2	.....
E.S.M. 2201	Statics	3-0-3	.....	.....
E.S.M. 3201-2	Dynamics I, II	.....	3-0-3	3-0-3
E.E. 3200	Elements of Electrical Engineering	.....	.....	2-3-3
Math. 2307	Calculus IV	5-0-5	.....	.....
Math. 2308	Calculus and Linear Algebra	.....	5-0-5	.....
Math. 2309	Differential Equations	.....	.....	5-0-5
Phys. 2122-3	Physics	4-3-5	4-3-5	.....
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective ³	Free	.....	.....	3-0-3
	Totals	15-6-17	15-9-18	16-3-17

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.S.M. 3111	Experiments in Engineering Science	.....	.....	3-0-3
E.S.M. 3301	Mechanics of Deformable Bodies	5-0-5	.....	.....
E.S.M. 3302	Mechanics of Materials	.....	3-0-3	.....
E.S.M. 3501	Fluid Mechanics	.....	.....	5-0-5
E.S.M. 4210	Mechanical Vibrations	.....	3-0-3	.....
E.E. 3400	Instrumentation Laboratory	.....	1-3-2	.....
M.E. 3726-7	Thermodynamics	4-0-4	3-0-3	.....
Elective	Either I.Sy.E. 4000, Introduction to Systems Theory, or M.E. 4445, Automatic Control	.....	.....	3-0-3
Elective ³	Mathematics	.....	.....	3-0-3
Elective	Technical	3-0-3	.....	.....
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	.....
Electives	Free	3-0-3	3-0-3	3-0-3
	Totals	18-0-18	16-3-17	17-0-17

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.S.M. 3451	Computer Applications in Engineering Science and Mechanics	3-0-3	.....	.....
E.S.M. 4121	Projects in Engineering Science	3-0-3	.....	.....
E.S.M. 4401	Materials Science	3-0-3	.....	.....
M.E. 4714	Heat Transfer	.....	.....	3-0-3

Senior Year (continued)

Course No.	Subject	1st Q.	2nd Q.	3rd Q.
Econ. 2000	Survey of Principles of Economics	.....	3-0-3	.....
Elective ³	Mathematics	.....	3-0-3	.....
Elective ⁴	Physics	.....	3-0-3	.....
Electives ⁵	Technical	.....	6-0-6	6-0-6
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives ²	Free	3-0-3	.....	5-0-5
	Totals	15-0-15	18-0-18	17-0-17

¹See College of Engineering section "Curricula and Degrees" for engineering electives.

²These free elective hours may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, then it should be scheduled beginning the first quarter the student is enrolled.

A maximum of nine hours of free electives in junior and senior years may be in advanced ROTC.

³To be selected from Math. 3110, 4215, 4321, 4581, 4582.

⁴To be selected from Phys. 3143, 3002 or 3751. If Phys. 3143 is chosen, the extra two credits will be used as technical electives.

⁵At least six hours of electives must be in the area of design, synthesis or systems.

⁶See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women.

Program in Health Systems

(Established in 1972, Option in 1958)

Director and Regents' Professor—Harold E. Smalley; *Associate Director and Professor*—A. D. Joseph Emerzian; *Professor*—John R. Watt; *Associate Professors*—J. Norman Berry (Adjunct), Raphael B. Levine (Adjunct), James B. Mathews, F. Levering Neely (Adjunct); *Assistant Professors*—Richard M. Bramblett, Michael S. Leonard; *Lecturer*—Howard E. Fagin.

General Information

Health systems is a new career field. As one of the allied health professions, it works to improve health care services while con-

trolling costs. It uses the systems approach, applies scientific methods and works with people to create real improvements.

A career in this field is challenging and rewarding in many ways. Health care is humanitarian and health services are important to society; the industry is large, expensive and in need of improvement. A career in health systems is an opportunity to use modern scientific methods in the performance of a vital public service.

Health systems specialists are in short supply and there are many job openings with hospitals, nursing homes, doctors' offices, government agencies, universities, medical centers, research and planning organizations, manufacturers of hospital equipment, health insurance companies, management consultants, architectural firms and construction contractors.

The program in health systems is an academic division of the College of Engineering and is administered by the faculty of the Health Systems Research Center. The program offers undergraduate and graduate health systems courses and administers programs of study for students enrolled in the B.S. curriculum in health systems.

The program is a direct outgrowth of faculty involvement in the field since 1952 and of a health related academic program begun at Georgia Tech in 1958; its faculty pioneered the field and is recognized worldwide as leaders in health systems education, research and community outreach service.

Baccalaureate Curriculum

The undergraduate curriculum in health systems was designed to prepare students for entry into the profession of health systems, and it provides an academically sound base for lifelong learning. Even though it is technical and analytical, the course of study places considerable emphasis upon interpersonal, organizational and societal relationships. Although it is directed toward the health field, the curriculum provides students with valuable knowledge and marketable skills needed in many different fields. Successful completion of this curriculum leads to the Bachelor of Science degree.

The program offers several unique features. It provides considerable flexibility so that students from various fields can transfer into it without losing credit already earned, it contains sufficient electives to accommodate various specialty interests and it contains a senior year practicum or externship that enables students to be involved in actual health systems work while still in college.

Modified versions of the health systems curriculum are available under the Dual Degree (3-2) Program.

Pre-Medical or Pre-Dental Programs

The undergraduate curriculum in health systems forms an excellent pre-medical or pre-dental program and it provides the systems orientation now being favored by leading medical educators. Health systems majors will satisfy the entrance requirements of most medical and dental schools by structuring their electives to include Biol. 1001, 1710 and 1711 as environmental electives, Chem. 2113, 3311, 3312, 3313, 3381 and 3384 as free electives and Engl. 1001, 1002 and 1003 as humanities electives. If the graduate is not admitted to or changes his mind about medical or dental school, he will be prepared to pursue a career in health systems.

Health Systems Tracks

In addition to students enrolled as majors in the baccalaureate curriculum in health systems, students enrolled in various other curricula may emphasize health systems by electing to follow health systems tracks. Presently, a formal health facilities planning track is available to undergraduate and graduate students in the School of Architecture and other formal tracks are planned for the future.

Graduate Programs

Health related graduate work leading to master's and doctoral degrees may be arranged under a special interdepartmental program. A graduate student wishing to emphasize health systems in his program of study may do so by obtaining approval of his own school and making application to the Health Systems Research Center. Such HSRC trainees typically follow regular curricula or core programs of their own schools, include a sequence of health systems courses as electives and engage in project work or student research under HSRC faculty direction. A new master's degree program in health systems is being planned for the future.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1101-2	General Chemistry	.....	4-3-5	4-3-5
E.Gr. 1170	Visual Communication	2-3-3	.....	.....

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
P.E. ² 1040	Health Education	.....	.....	3-0-3
Electives ¹	Humanities/Modern Language/Social Science	6-0-6	6-0-6	3-0-3
Electives ³	Free	<u>2-0-2</u>	<u>2-0-2</u>	<u>2-0-2</u>
	Totals	15-3-16	17-3-18	17-3-18

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Econ. ⁴ 2000-1	Economic Principles and Problems	3-0-3	3-0-3	.....
H.S. 2011	Introduction to the Health Field	.....	.....	3-0-3
Math. 2010	Finite Mathematics	5-0-5	.....	.....
Phys. 2121-2-3	Engineering Physics	4-3-5	4-3-5	4-3-5
Electives ¹	Humanities/Modern Language/Social Science	3-0-3	3-0-3	3-0-3
Electives	Either I.C.S. 1700 or E.E. 1010, Digital Computer Organi- zation and Pro- gramming	.....	2-3-3	.....
	Either I.C.S. 2700 or Mgt. 3050, Com- puter and Program- ming Systems	.....	.....	3-0-3
	Either Math. 2205-6 or M.Sci. 3110-1, Elementary Statis- tical Analysis	<u>.....</u>	<u>3-0-3</u>	<u>3-0-3</u>
	Totals	15-3-16	15-6-17	16-3-17

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
H.S. 3011	Hospital Functions and Problems	3-0-3	.....	.....
H.S. 3121	Work Measurement in the Health Services	.....	3-0-3	.....
H.S. 3131	Health Systems, Processes and Facilities	.....	.....	2-3-3
H.S. 3211	Data Processing in the Health Services	.....	3-0-3	.....
H.S. 3351	Health Systems Projects and Reports	.....	.....	3-0-3
I.Sy.E. 3015	Analysis of Production Operations	4-0-4	.....	.....
I.Sy.E. 4725	Engineering Economy	.....	3-0-3	.....
Mgt. 3700	Analysis of Financial Data	3-3-4	.....	.....
M.Sci. 3400-3	Analytical Methods in Management IV	.....	3-0-3	3-0-3
Psy. ⁴ 3303	General Psychology A	3-0-3	.....	.....
Psy. 4405	Seminar in Organizational Psychology	.....	.....	3-0-3
Psy. ⁴ 4410	Social Psychology	.....	3-0-3	.....
Electives ⁵	Free	3-0-3	3-0-3	3-0-3
	Totals	16-3-17	18-0-18	14-3-15

Senior Year / Practicum Option⁶

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
H.S. 4471-2-3	Health Systems Practicums	0-12-4	0-12-4	0-12-4
H.S. 4691	Health Systems Seminar	.....	.....	2-0-2

Senior Year / Practicum Option⁶ (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Elective	Either H.S. 4765 or I.Sy.E. 4765, Hos- pital Management Systems	.....	3-0-3	.....
Elective ⁷	Health Systems	3-0-3	.....	.....
Electives ⁸	Technical	3-0-3	3-0-3	3-0-3
Electives ⁹	Environmental	3-0-3	3-0-3	3-0-3
Electives ⁵	Free	3-0-3	3-0-3	.....
	Totals	12-12-16	12-12-16	8-12-12

Senior Year / Externship Option¹⁰

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
H.S. ¹⁰ 4581	Health Systems Externship	.....	0-36-12	.....
H.S. 4691	Health Systems Seminar	.....	.....	2-0-2
Elective	Either H.S. 4765 or I.Sy.E. 4765, Hos- pital Management Systems	.....	.....	3-0-3
Elective ⁷	Health Systems	3-0-3	.....	.....
Electives ⁸	Technical	6-0-6	.....	3-0-3
Electives ⁹	Environmental	6-0-6	.....	3-0-3
Electives ⁵	Free	3-0-3	.....	3-0-3
	Totals	18-0-18	0-36-12	14-0-14

¹See "Information for Undergraduate Students" for humanities and social science electives.

²P.E. 1040 is required of all health systems majors. In addition, men must take two more P.E. courses, one of which must be P.E. 1010. Excess P.E. hours will apply toward satisfaction of elective hour requirements.

³These free elective courses may be taken at any time during the course of study. If ROTC is elected by the student these six credit hours may be applied for basic ROTC, which should be scheduled beginning the first quarter the student is enrolled.

⁴These courses will apply toward satisfaction of the social science requirements stated in "Information for Undergraduate Students."

*Suggestions to aid the student in his free choice will be provided by the HSRC faculty; however, the student should plan his electives with a view toward satisfying the humanities and social science requirements given in "Information for Undergraduate Students," the U.S. and Georgia history and constitution requirements, and the rising junior English examination.

*Under the practicum option, students work one-third time for three quarters on real problems assigned to them in local institutions.

*The student may choose any course with the H.S. prefix or a substitute course approved by the HSRC faculty.

*These are courses that emphasize principles and techniques useful in analyzing or improving management systems and are to be selected from among courses approved by the HSRC faculty.

*These are courses that describe the health field, medical affairs, the life sciences, the community or other aspects of the environment in which the graduate will practice, and are to be selected from among courses approved by the HSRC faculty.

*Under the externship option, students work full-time for one quarter on real problems assigned to them at affiliated institutions or agencies, some outside Atlanta. It is suggested that students in this option schedule the externship in the first or second quarter of the senior year.

School of Industrial and Systems Engineering

(Established in 1945 — Option in M.E., 1924-1945)

Director—Robert N. Lehrer, Frank F. Groseclose (Emeritus); *Associate Director for Undergraduate Programs*—Nelson K. Rogers; *Associate Director for Graduate Programs*—William W. Hines; *Professors*—James M. Apple, Leslie G. Callahan, Paul T. Eaton (Emeritus), David E. Fyfe, Cecil G. Johnson, Lynwood A. Johnson, Joseph Krol, C. M. Shetty, Rocker T. Staton, Harrison M. Wadsworth, Jr.; *Associate Professors*—Jerry Banks, Mokhtar S. Bazaraa, J. Gordon Davis, Stuart J. Deutsch, Augustine O. Esogbue, Willard R. Fey, John J. Jarvis, Paul S. Jones, James B. Mathews, Douglas C. Montgomery, Nelson K. Rogers, Frank E. Roper, Thomas L. Sadosky, Gerald J. Thuesen, V. E. Unger, Jr.; *Assistant Professors*—Kailash N. Bafna, Terence Connolly, Richard H. Deane, Robert J. Graves, Russell G. Heikes, Tarald O. Kvalseth, R. Gary Parker, Ronald R. Rardin, Rodney K. Schutz, Gunter P. Sharp, I. Gayden Thompson, Donavan B. Young; *Instructor*—F. B. Alt, *Lecturers*—Richard Fuller (Adjunct), George W. Greenwood (Adjunct), Clark Gregory.

General Information

Industrial and systems engineering provides both a basic engineering foundation and a grounding in the interactions

between technology and management. Students in the program are usually interested in obtaining a fundamental engineering background as the basis for professional specialization in activities associated with the field—operations research, management science, system engineering, methods, organization, planning—or as preparation for other endeavors, such as management. The study of industrial and systems engineering places emphasis upon developing the student's abilities to analyze and design systems that integrate technical, economic and social-behavioral factors in industrial, service, social and governmental organizations. Two bachelor degree programs are offered: the Bachelor of Industrial Engineering (B.I.E.) and the Bachelor of Engineering Economic Systems (B.E.E.S.).

B.I.E.

The principal strength of the program leading to the Bachelor of Industrial Engineering degree lies in a solid, well-coordinated core of courses in systems analysis and systems design, which relies heavily upon the engineering sciences, basic sciences and social sciences. Elective hours make the program flexible as does the senior year design sequence, which permits a student to place emphasis on operations and facilities system design, information and control systems design, systems engineering or a variety of other aspects of the field.

B.E.E.S.

The program leading to the Bachelor of Engineering Economic Systems degree provides preparation for dealing with systems problems in the socio-economic sector. The program provides for a background in physical science and in behavioral or social science, and a grounding in the concepts and methodologies associated with systems analysis, industrial and systems engineering, computer technology, operations research and management science. Opportunity is also provided to develop insight and background in specific areas of socio-economic problems by means of selected course work under the major selection requirement. A senior-year project facilitates integration of earlier course work in dealing with selected project problems.

Options for Exceptional Students

An option program is available to encourage students with superior abilities to fully avail themselves of a range of a unusual educational opportunities.

Participation in these programs requires demonstrated scholastic excellence, prior arrangements with the student's adviser and provides the following options, individually or in combination.

Graduate level courses in lieu of senior year electives. Students with a cumulative grade-point average of 3.3 or above may schedule up to 18 credit hours of approved graduate level courses. For such students, up to 18 credit hours of senior-year electives may be waived. These credits, when approved by the student's adviser, may be made available for subsequent credit toward a graduate degree.

Accelerated study. Students with a 3.3 or above average during the three preceding quarters (including at least 45 credits), may complete course requirements for any non-project industrial and systems engineering course at their own pace by self study with counseling and guidance by the course instructor. Students may register for any number of courses but must satisfy instructor and course examination requirements. This may be done by the student's own timing. Class attendance is not required. Arrangements must be made with course instructors prior to the start of the quarter.

Individual project and research work. Students with a 3.0 or above average during the preceding three quarters (including at least 45 credits) may schedule up to 18 credits of project or research work or both, done in collaboration with the faculty or advanced graduate students, which may be substituted for senior-year electives.

Director's honor seminar. I.Sy.E. 4500 for senior students with a 3.0 or above cumulative grade point average. It may be taken as an elective.

Governor's intern program. I.Sy.E. seniors enrolled in the governor's intern program may receive eight hours of design credit (4051, 4052) and six hours of I.Sy.E. elective credit (4995) for participation in the program.

Visiting Scholar/Practitioner Offerings

Upon occasion, the school brings to campus selected individuals of unique accomplishment for course offerings built around their special area of activity, thus making available a broader range of course materials than regularly provided. The typical schedule is Friday afternoon and evening instruction four times during the quarter.

Graduate Programs

The School of Industrial and Systems Engineering offers graduate programs leading to the degrees Master of Science in Industrial Engineering, Master of Science, Master of Science in Operations Research and Doctor of Philosophy.

The M.S.I.E. program is available for students holding the B.I.E. degree and for other engineers who satisfy requisites covering the principal subject matter of the current B.I.E. curriculum. The M.S.O.R. program is available for students holding the B.S. in engineering, mathematics or science. Requisites include work in probability, statistics, linear algebra, advanced calculus and optimization. The requisite requirements may be satisfied after enrollment, however, such course work may not be applied to satisfy degree requirements.

The undesignated M.S. is intended for those students who desire to follow programs in applied statistics, systems engineering, human activity systems or other special programs.

For each of the above master's programs, a student has two options: either thirty-three quarters hours of course work and a thesis or fifty quarter hours of course work and a written comprehensive examination.

The doctoral program is intended for highly gifted individuals whose past accomplishments and evaluations indicate a high potential for successful completion of the program requirements and a subsequent creative contribution to the field. Admission is, therefore, dependent upon student qualification rather than educational background in any specified discipline.

All degree curricula of the school are offered on a 12-month basis. Graduate programs may be started in any quarter.

Financial aid is available in the form of traineeships, fellowships and research assistantships.

The B.I.E. Curriculum

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Engl. 1001-2-3	Introduction to Literature	3-0-3	3-0-3	3-0-3
Chem. 1101-2	General Chemistry	4-3-5	4-3-5	.....

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Phys. 2121	Particle Dynamics	.....	.....	4-3-5
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
E.Gr. 1170	Visual Communications and Engineering Design I	2-3-3	.....	.....
Elective ^a	Engineering	.....	X-X-3	.....
I.C.S. 1700	Digital Computer Organ- ization and Program- ming	.....	.....	2-3-3
Electives ¹	Physical Education	0-4-1	0-4-1	0-4-1
Electives ²	Free	2-0-2	2-0-2	2-0-2
	Totals	16-10-19	16-10-19	16-10-19

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ³	Humanities	3-0-3	3-0-3	3-0-3
Phys. 2122	Electromagnetism	4-3-5	.....	.....
Phys. 2123	Optics and Modern Physics	.....	4-3-5	.....
E.S.M. 2201	Statics	.....	.....	3-0-3
Math. 2307	Calculus IV	5-0-5	.....	.....
Math. 2308	Calculus V	.....	5-0-5	.....
Math. 2309	Differential Equations	.....	.....	5-0-5
Econ. 2000-1	Principles of Economics	3-0-3	3-0-3	.....
I.Sy.E. 2000	Introduction to Indust- rial and Systems Engineering	.....	.....	3-0-3
Elective	History	.....	.....	3-0-3
	Totals	15-3-16	15-3-16	17-0-17

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.S.M. 3201	Dynamics I	3-0-3	.....	.....
E.E. 3700	Elements of Electric Circuits and Instruments	.....	3-0-3	.....
M.E. 3720	Thermodynamics	.....	.....	4-0-4
Mgt. 3700	Analysis of Financial Data	3-3-4	.....	.....
I.Sy.E. 3027	Applications of Prob- ability	3-0-3	.....	.....
I.Sy.E. 3208	Engineering Statistics I	.....	3-0-3	.....
I.Sy.E. 3029	Engineering Statistics II	.....	.....	3-0-3
I.Sy.E. 3033	Deterministic Models in Operations Re- search	4-0-4	.....	.....
I.Sy.E. 3010	Man-Machine Systems	.....	3-0-3	.....
I.Sy.E. 3025	Engineering Economy	.....	3-0-3	.....
I.Sy.E. 4044	Simulation	.....	.....	2-3-3
I.Sy.E. 4048	Systems Design Methodology	.....	.....	3-0-3
Electives ⁴		3-0-3	3-0-3	3-0-3
	Totals	16-3-17	15-0-15	15-3-16

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.S.M. 3301	Mechanics of Deform- able Bodies	5-0-5	.....	.....
Elective ⁵	Material Science	.....	3-0-3	.....
Electives ⁶	Design I, II	2-6-4	2-6-4	.....
Electives ⁴		7-0-7	9-0-9	12-0-12
	Totals	14-6-16	14-6-16	12-0-12

¹See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women.

²These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled beginning the first quarter the student is enrolled.

³See "Information for Undergraduate Students" for humanities electives to satisfy the College of Engineering requirements.

⁴Electives will include 12 hours of social science; 18 hours of industrial and systems engineering and 16 hours of free electives. The 16 hours of free electives may be used to accommodate basic ROTC, six credits, and advanced ROTC, nine credits. Students must select social science courses which satisfy the College of Engineering requirements. Ordinarily B.I.E. students schedule I.Sy.E. electives during their junior year.

⁵Listings of courses approved to satisfy these electives are available in the office of the School of Industrial and Systems Engineering.

⁶The Design I and II requirements may be satisfied by selecting I.Sy.E. 4071 and 4072, 4081 and 4082, 4061 and 4062 or 4051 and 4052.

⁸See College of Engineering section "Curricula and Degrees" for freshman engineering electives.

The B.E.E.S. Curriculum

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Engl. 1001-2-3	Introduction to Literature	3-0-3	3-0-3	3-0-3
Electives ¹	Science	5-0-5	5-0-5	.....
Phys. 2121	Particle Dynamics	.....	.....	4-3-5
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
I.Sy.E. 1010	Basic Concepts of Industrial and Systems Engineering	.....	2-3-3	.....
Elective	History	3-0-3	.....	.....
Elective ²	Computer Science	.....	.....	2-3-3
Electives ³	Physical Education	0-4-1	0-4-1	0-4-1
Electives ⁴	Free	2-0-2	2-0-2	2-0-2
	Totals	18-4-19	17-7-19	16-10-19

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Psy. 3303-4	General Psychology A,B	3-0-3	3-0-3	.....
Psy. 4410	Social Psychology	.....	.....	3-0-3

Sophomore Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Phys. 2122	Electromagnetism	4-3-5	.....	.....
Phys. 2123	Optics and Modern Physics	.....	4-3-5	.....
Math. 2307	Calculus IV	5-0-5	.....	.....
Math. 2308	Calculus V	.....	5-0-5	.....
Math. 2309	Differential Equations	.....	.....	5-0-5
Econ. 2000-1	Principles of Economics	3-0-3	3-0-3	.....
Elective ⁷	Economics	.....	.....	3-0-3
I.Sy.E. 2001	Projects	.....	.....	0-6-2
I.Sy.E. 2000	Introduction to I.Sy.E.	.....	.....	3-0-3
	Totals	15-3-16	15-3-16	14-6-16

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
P.H.S. 3117-8-9	History of Engineering	3-0-3	3-0-3	3-0-3
Electives ⁵	Major Selection	3-0-3	3-0-3	3-0-3
Mgt. 3700	Analysis of Financial Data	3-3-4	.....	.....
I.Sy.E. 3027	Application of Probability	3-0-3	.....	.....
I.Sy.E. 3028	Engineering Statistics I	.....	3-0-3	.....
I.Sy.E. 3029	Engineering Statistics II	.....	.....	3-0-3
I.Sy.E. 3033	Deterministic Models in Operations Research	4-0-4	.....	.....
I.Sy.E. 3010	Man-Machine Systems	.....	3-0-3	.....
I.Sy.E. 3025	Engineering Economy	.....	3-0-3	.....
I.Sy.E. 4044	Simulation	.....	.....	2-3-3
I.Sy.E. 4048	Systems Design Methodology	.....	.....	3-0-3
Elective	Free	.....	.....	2-0-2
	Totals	16-3-17	15-0-15	16-3-17

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ⁹	Humanities	3-0-3	3-0-3	3-0-3
Electives ⁶	Sociology or Political Science	3-0-3	3-0-3	3-0-3
Electives	I.Sy.E.	3-0-3	3-0-3	6-0-6
Electives ⁷	Economics	3-0-3	3-0-3	.....
Electives ⁸	Projects I, II or Design I, II	0-12-4	0-12-4	.....
	Totals	12-12-16	12-12-16	12-0-12

¹The requirement for science may be satisfied by Chem. 1101-2 or by other natural and/or life science courses approved by the student's department for a total of ten credits.

²An appropriate computer course, or demonstrated ability to effectively use the computers on campus, may be substituted for this requirement. Substitution must be approved by the School of Industrial and Systems Engineering.

³See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women. A maximum of six credit hours of P.E. courses may be used for degree credit.

⁴These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled beginning the first quarter the student is enrolled.

⁵The major selection should provide the student with additional background relative to the application area of most interest to him, and will likely be involved in his project work. Major selections should be discussed with the student's adviser, and must be approved by him. The resources of all educational organizations in the Atlanta area should be considered, particularly the offerings of Georgia State University.

⁶The sociology or political science selections may be satisfied by courses in sociology, political science or any behavioral sciences which are acceptable to and approved by the student's adviser. Offerings of Georgia State University may be used to satisfy this requirement.

⁷Three additional courses in economics must be included in each student's program. These courses may be taken as electives in the sophomore and senior year. A detailed list of approved economic electives is available from the office of the School of Industrial and Systems Engineering.

⁸The project work is intended as an integrative experience for the student dealing with socio-economic problems related to the student's major selection. Project work usually involves dealing with a live situation and field activity for gathering data, problem definition and direct interaction with those individuals involved within the problem setting. It also usually requires pilot implementation of project results and recommendations. Detailed information concerning the requirements of the project work is available from the office of the School of Industrial and Systems Engineering.

⁹See "Information for Undergraduate Students" for humanities elective to satisfy the College of Engineering requirement.

School of Mechanical Engineering

(Established in 1888)

Director and Professor—Stothe P. Kezios; *Professor and Director Emeritus*—Homer S. Weber; *Regents' Professor Emeritus*—Joseph P. Vidosic; *Professor Emeritus*—Richard A. Trotter; *Whirlpool Professor*—John Berry; *Professor of Energy Engineering*—Thomas Jackson; *Professors*—Allan D. Pierce*, Ward O. Winer; *Visiting Professor*—K. E. Hassan, Professor of Thermal Power, University of Cairo; *Associate Professors*—W. Z. Black*, Gene T. Colwell, P. V. Desai, S. L. Dickerson*, P. Durbetaki, A. L. Holliman, H. L. Johnson, P. V. Kadaba, S. V. Shelton, J. Richard Williams, Wolfgang Wulff; *Assistant Professors*—M. R. Corley, R. B. Evans, W. J. Hadden, Jr., C. H. Jacobs, W. D. McLeod, D. M. Sanborn, W. M. Williams; *Senior Research Engineer*—U. H. Bauder; *Research Engineer*—Calvin Lee; *Lecturers*—J. W. Brazell, David Kalish, John Murphy.

General Information

Mechanical engineering continues to be one of the most viable engineering disciplines because of its general nature and breadth of scope, having traditionally dealt with perhaps the largest diversity of engineering problems. This general nature of mechanical engineering allows a number of multidisciplinary activities to be comfortably organized under it without taxing the credulity of their identification.

Mechanical engineering embraces such diverse activities as the generation, conversion, transmission and utilization of thermal and mechanical energy, the design and production of tools and machines and their products, the consideration of fundamental characteristics of materials as applied to design and the synthesis and analysis of mechanical, thermal and fluidic systems and their individual components, including feedback and control. Design, production, operation, administration, economics and research are functional aspects of mechanical engineering.

The undergraduate curriculum covers the fundamental aspects of the field, impresses basic principles upon the student and educates him in the use of these principles to reach optimal design solutions for engineering situations and problems. Specific design subject matter and materials are drawn from such newer engineering activities as oceanography and biomechanical systems, as well as from the more traditional areas.

Emphasis in the freshman and sophomore years is traditionally

*Associate Directors

on mathematics, chemistry and physics, and in the junior and senior years on the strength and metallurgy of materials, applied mechanics, thermodynamics, heat transfer, fluid mechanics and the application of those fundamental subjects to the diverse problems of mechanical engineering. Nevertheless, it is possible to experience aspects of creative decisions and designs at the freshman level. Laboratory work and design projects are stressed.

Satisfactory completion of the curriculum leads to the degree Bachelor of Mechanical Engineering.

Optional Programs

While the curriculum is structured to meet the general educational goals of the majority of mechanical engineering students, the school regularly considers and approves major modifications of the basic program to allow a student with certain well defined educational objectives to pursue minor fields within the school or within Georgia Tech while earning a degree in mechanical engineering. In this way a student may achieve his basic degree in mechanical engineering while minoring in any one of a large number of other fields. Aside from the broad flexibility afforded by such special programs, a student following the regular M.E. curriculum takes a number of electives as well as special problems and projects, all of which allow latitude in pursuing his educational goals and special interests.

Graduate Programs

The School of Mechanical Engineering has a rapidly expanding and vigorous graduate program of advanced study and research in the areas of acoustics and noise control, automatic controls, bioengineering, combustion, complex systems design, controlled machine tools, dynamics and vibration, energy engineering, engineering design, environmental quality control, flammability, fluid mechanics, fluidics and fluid power, heat transfer, design for extreme temperatures, lubrication, magnetogasdynamics and plasma, manufacturing engineering, materials processing, materials science and engineering mechanisms (synthesis and analysis), nuclear power, power and propulsion, thermal systems (analysis and design), thermodynamics (equilibrium and irreversible), transport processes and two-phase flows.

These graduate programs lead to the degrees Master of Science in Mechanical Engineering, Master of Science and Doctor of Philosophy for qualified graduates having backgrounds in

engineering, mechanics, mathematics, physical sciences and biological sciences.

Multidisciplinary Programs

The school participates in many of the multidisciplinary programs of the College of Engineering: acoustics engineering, bioengineering, computer engineering, educational engineering, energy engineering, engineering design, environmental engineering, manufacturing engineering, materials engineering, ocean engineering, paper engineering, systems engineering, transportation engineering and urban engineering.

School Facilities

The School of Mechanical Engineering has many types of specialized instruments and equipment associated with laboratories for the study of two-phase flow, lubrication and rheology, material processing, fire hazard and combustion, magnetogasdynamics, energetics, fluidics and fluid power control, heat transfer, vibration and thermal stress, automatic and digital control, machinery noise, and other areas. The school is housed in a four-building classroom-research complex. Part of this complex is a classroom-seminar conference building with modern facilities serving the institute.

The main research building of the school houses several remote terminals linked to the main campus research and teaching computer, as well as analog computers and electronic calculators with programming capabilities. The school research activity is served by its own machine and instrumentation shops with a full-time supporting staff of technicians.

Additional information about the programs may be obtained from the school's *Student Handbook* or *Graduate Brochure*, available upon request, or by calling the school at (404) 894-3203. These sources of information must be consulted with respect to special rules and degree requirements by every student enrolled.

Freshman Year

Course No.	Subject	1st Q.	2nd Q.	3rd Q.
Chem. 1101-2	General Chemistry	4-3-5	4-3-5	.....
Phys. 2121	Particle Dynamics	.....	.....	4-3-5
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Elective	E.Gr. 1170, Introduction to Visual Communication and Engineering Design I (2-3-3) and one of the engineering electives ¹	X-X-3	X-X-3	.....
M.E. 1001	Introduction to M.E.	.....	.....	1-0-1
Electives ⁴	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives ⁵	Physical Education	0-4-1	0-4-1	0-4-1
Electives ²	Free	2-0-2	2-0-2	2-0-2
	Totals	16-10-19	16-10-19	15-17-17

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Phys. 2122	Electromagnetism	4-3-5	.....	.....
Phys. 2123	Optics and Modern Physics	.....	4-3-5	.....
Math. 2307	Calculus IV	5-0-5	.....	.....
Math. 2308	Calculus and Linear Algebra	.....	5-0-5	.....
Math. 2309	Differential Equations	.....	.....	5-0-5
E.S.M. 2201	Statics	3-0-3	.....	.....
E.S.M. 3201	Dynamics I	.....	3-0-3	.....
E.S.M. 3301	Mechanics of Deformable Bodies	.....	.....	5-0-5
M.E. 2212	Materials Science	.....	.....	3-0-3
Electives ⁴	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
	Totals	15-3-16	15-3-16	16-0-16

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
M.E. 3322-3-4	Thermodynamics	3-0-3	3-0-3	3-0-3
M.E. 3342-3-4	Transport Phenomena I, II, III	3-0-3	3-0-3	3-3-4
E.E. 3725	Electric Circuits and Fields	2-3-3	.....	.....
E.E. 3726	Elementary Elec- tronics	.....	2-3-3	.....
E.E. 3727	Electric Power Conversion	.....	.....	2-3-3
M.E. 3212	Materials Technology	3-3-4	.....	.....
M.E. 3016	M.E. Computer Applications	.....	2-3-3	.....
M.E. 3055	Experimental Methodology	.....	.....	1-3-2
M.E. 3113	Mechanisms, Analysis and Synthesis	3-0-3	.....	.....
M.E. 3114	Dynamics of Machinery	.....	3-0-3	.....
Electives ⁴	Humanities/Social Science/Modern Language	.....	3-0-3	6-0-6
	Totals	14-6-16	16-6-18	15-9-18

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
M.E. 4181	Machine Elements	3-3-4	.....	.....
M.E. 4183	Design Theory	.....	3-0-3	.....
M.E. 4184	Design Engineering	.....	.....	0-6-2
M.E. 4316-7	Thermal Systems Analysis I, II	3-0-3	2-3-3	.....
M.E. 4055	Experimental Engi- neering	.....	.....	1-3-2

Senior Year (continued)

Course No.	Subject	1st Q.	2nd Q.	3rd Q.
M.E. 4344	Transport Phenomena IV	3-0-3	.....	.....
M.E. 4212	Material Processes	.....	3-3-4	.....
M.E. 4445	Automatic Control	3-0-3	.....	.....
I.Sy.E. 4725	Engineering Economy	.....	.....	3-0-3
Electives ³	Technical	3-0-3	3-0-3	3-0-3
Electives ⁴	Humanities/Social Science/Modern Language	.....	3-0-3	6-0-6
	Totals	15-3-16	14-6-16	13-9-16

¹See College of Engineering section "Curricula and Degrees" for engineering electives.

² These free elective courses may be taken at any time during the course of study. If ROTC is elected by the student these six credit hours may be applied for basic ROTC, which should be scheduled beginning the first quarter the student is enrolled.

³ Nine hours of technical electives chosen from M.E. 4000 and 6000 level courses. Graduate courses (6000 level) must have consent of adviser. Courses other than these may be selected from mathematics, physics, chemistry, biology, another field of engineering or graduate courses. A student who wishes to take courses not in M.E. must so notify the director of his choice and obtain approval at advance registration for the first quarter of his senior year. A lab course (2-3-3) may be scheduled in place of a (3-0-3) course.

A student completing his junior year with a grade average of 2.5 or higher may elect one technical elective from the special problem courses M.E. 4901 through 4912. (The particular course selected depends on the number of hours of credit needed.) This student will follow a course of individual study under the guidance of a faculty member with the approval of the school director. Nine hours of electives may be replaced by advanced ROTC.

⁴ For selection of acceptable courses see list of electives allowed by the College of Engineering in "Information for Undergraduate Students."

⁵See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshmen physical education requirements for both men and women.

School of Nuclear Engineering

(Established in 1962)

Director—L.E. Weaver; *Neely Professor*—K. Z. Morgan; *Professors*—M. W. Carter, J. D. Clement, M. V. Davis, G. G. Eichholz, D. S. Harmer, C. J. Roberts; *Associate Professors*—R. J. Johnson, J. M. Kallfelz, R. A. Karam, J. H. Rust; *Assistant Professors*—R. W. Carlson, J. N. Davidson, P. H. McGinley.

General Information

Nuclear engineering is the branch of engineering directly concerned with the release, control and utilization of all types of energy from nuclear sources and its environmental impact. Today nuclear energy is being used in a wide variety of applications from the exploration of outer space and the powering of human heart pacemakers to the generation of electricity. With the limited supply of fossil fuels and the growing concern about their environmental effect, the need for nuclear power to produce the large amounts of energy demanded by our society becomes more and more pressing. The School of Nuclear Engineering is playing a vital role in educating the technical manpower required to meet this need. The faculty members are well respected in their chosen specialities and are concerned with the total development of the student.

Undergraduate Program

The curriculum leading to the degree Bachelor of Nuclear Engineering is structured to meet the needs of both the student who contemplates employment after graduation and the student planning to pursue graduate study. It has been tailored to provide maximum flexibility in the form of options for each student to develop his or her unique interests or capabilities. These options are built upon the core curriculum covering the basic principles of nuclear engineering: nuclear reactor core design, nuclear fuel design, reactor controls engineering, nuclear fuel process engineering, nuclear power economics, nuclear power management, nuclear methods development and reactor operations. In addition, several courses are available in health physics.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1101-2	General Chemistry	4-3-5	4-3-5	.....
Phys. 2121	Particle Dynamics	.....	.....	4-3-5
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
E.Gr. 1170	Visual Communication and Engineering Design	.....	2-3-3	.....
Elective ¹	Engineering	2-3-3	.....	.....

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ⁶	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives ⁵	Physical Education	0-4-1	0-4-1	0-4-1
Elective ²	Free	.....	.....	3-0-3
	Totals	14-10-17	14-10-17	15-7-17

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Phys. 2122	Electromagnetism	4-3-5	.....	.....
Phys. 2123	Optics and Modern Physics	.....	4-3-5	.....
Math. 2307	Calculus IV	5-0-5	.....	.....
Math. 2308	Calculus and Linear Algebra	.....	5-0-5	.....
Math. 2309	Ordinary Differential Equations	.....	.....	5-0-5
E.S.M. 2201	Statics	.....	3-0-3	.....
E.S.M. 3201	Dynamics	.....	.....	3-0-3
E.E. 1010 ³	Computer Program- ming and Graphics	.....	.....	2-3-3
Electives ²	Free	4-0-4	.....	4-0-4
Electives ⁶	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3'
	Totals	16-3-17	15-3-16	17-3-18

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Phys. 3001	Modern and Nuclear Physics	5-0-5	.....	.....

Junior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
N.E. 4412	Principles of Health Physics	.....	3-0-3	.....
N.E. 3110	Radiation Detection	.....	.....	2-6-4
Met. 4403 ³	Introductory Nuclear Metallurgy	3-3-4	.....	.....
M.E. 3720 ³	Thermodynamics	.....	.....	4-0-4
Ch.E. 3304-5 ³	Transport Phenomena	.....	3-3-4	3-3-4
E.E. 3725	Electric Circuits and Fields	2-3-3	.....	.....
Math. 4582	Advanced Engineering Math	3-0-3	.....	.....
Math. 4581 ³	Advanced Engineering Math	.....	3-0-3	.....
Electives ⁶	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives ⁴	Technical	.....	3-0-3	3-0-3
	Totals	16-6-18	15-3-16	15-9-18

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
N.E. 4201-2	Nuclear Reactor Physics I and II	3-0-3	3-0-3	.....
N.E. 4211-2	Reactor Engineering I and II	3-0-3	3-0-3	.....
N.E. 4230	Nuclear Engineering Design	.....	.....	2-6-4
N.E. 4205	Reactor Laboratory	.....	.....	1-6-3
N.E. 4001-2-3	Nuclear Engineering Seminar	1-0-0	1-0-0	1-0-0
N.E. 4160	Radiation Transport and Shielding	.....	2-3-3	.....

Senior Year (continued)

Course No.	Subject	1st Q.	2nd Q.	3rd Q.
Ch.E. 4431 ³	Chemical Engineering Economics	3-0-3	.....	.....
Electives ⁶	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives ⁴	Technical	6-0-6	6-0-6	4-0-4
	Totals	19-0-18	18-3-18	11-12-14

¹For selection of College of Engineering approved elective courses and requirements see "Curricula and Degrees."

²Free elective courses may be taken at any time during the course of study. If ROTC is elected by the student, six credit hours may be applied for basic ROTC and a maximum of nine credit hours for advanced ROTC.

³Other courses may be substituted for these required courses. Substitutions are available from the general office of the School of Nuclear Engineering.

⁴The electives will be selected by the student after consultation with his adviser. At least seven credit hours must be in the area of engineering science and at least ten credit hours in the areas of design, synthesis and systems.

⁵See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁶See "Information for Undergraduate Students."

Graduate Program

The School of Nuclear Engineering administers programs leading to the degrees Master of Science in Nuclear Engineering, Master of Science, Master of Applied Nuclear Science and Doctor of Philosophy.

The program at the master's level provides nine areas of emphasis: reactor engineering, reactor operations, nuclear fuels engineering, energy systems engineering, computer applications, nuclear power management, radiation technology, environmental engineering and health physics.

These curricula are constructed from various combinations of nuclear engineering courses, supplemented with courses in other schools as appropriate. For the first eight areas, students with a bachelor's degree in engineering will take the Master of Science in Nuclear Engineering degree while students with a bachelor's degree in science will enroll for the Master of Science degree. Students completing studies in health physics will receive the Master of Applied Nuclear Science degree. Those students in computer applications, radiation technology and environmental

engineering may elect to receive the Master of Applied Nuclear Science degree, contingent upon their plan of study.

Depending on the career objectives of the student, a thesis may be encouraged as part of the Master of Science program. When appropriate, approved courses and research experience on a special problem may be substituted for a thesis.

The doctoral program is designed with great latitude to capitalize on variations in experience and interests of individual students. In addition to the courses offered by the School of Nuclear Engineering, students are encouraged to enroll in courses related to their subject areas that are offered by other schools.

Facilities

The facilities available on the Georgia Tech campus for instruction and research in nuclear engineering include the following: a five megawatt research reactor, a low-power training reactor, a sub-critical assembly, a 100,000 curie cobalt-60 source, several small digital computers, a UNIVAC 1108 computer, hot cells for handling radioactive materials, a complete nuclear instrumentation laboratory, a one million volt Van der Graaff generator and a pulsed neutron generator.

School of Textile Engineering

(Established in 1899)

Director—W. Denney Freeston, Jr.; *Callaway Professor*—John L. Lundberg; *Professors*—Winston C. Boteler, Walter C. Carter; *Associate Professors*—David R. Gentry, Ralph C. Lathem, Wayne C. Tincher; *Assistant Professor*—L. Howard Olson, Rick A. Porter, Amad H. Tayebi.

General Information

Textiles, one of man's oldest commercial ventures, continues to find new applications in the modern world. Fiber assemblies have many varied uses in our everyday life and are playing critical roles in many new complex systems in space, medicine, safety, environmental control, transportation and construction.

Textile engineering encompasses the synthesis of polymers by nature and man, fiber fabrication processes, assembling of fibers into one-, two- and three-dimensional structures, modification of structural properties through dyeing, finishing and coating, and

measurement of complex aesthetic and mechanical properties of fiber-based systems. New polymers and fibers, new methods of assembling fibers into useful products and new applications of fibers are being developed continually.

The School of Textile Engineering prepares students for rewarding careers in the polymer-fiber-textile industry. Graduates have positions in manufacturing supervision, technical service, sales, product and process development, research, quality control and corporate management. They participate in the design, development, manufacturing and marketing of a broad range of fiber-based and associated products. Many hold key management decision-making positions at a young age.

The textile industry is by far the largest manufacturing industry and employer in the Southeast. If apparel and other associated segments of the industry are included, the textile-based industry is the largest in the United States, representing one out of every eight manufacturing jobs. This is more than five times the number employed in the automobile industry. The textile industry's needs for textile graduates each year far exceed the number graduated.

Curricula

Three study programs are available leading to the degrees Bachelor of Textile Engineering, Bachelor of Science in Textile Chemistry and Bachelor of Science in Textiles. Each degree may be pursued in a regular four-year program or the five-year cooperative plan.

A broad background is stressed because of the multidisciplinary nature of textiles. Emphasis in the freshman and sophomore years is on mathematics, chemistry and physics, in the junior and senior years on materials science, polymer and textile chemistry, applied mechanics, business administration and application of each field to the broad range of problems encountered in textiles. All three programs provide for student selection of a number of courses from a wide range of general and technical electives.

In place of the conventional laboratory sessions, textile students participate in a student operated and managed business venture. Students design, develop, produce and market novelty textile products. Every participant is exposed to all facets of the business environment.

Since most of the course work in textiles is concentrated in the last two years of the programs, students from junior colleges and community colleges can readily transfer into selected programs of the School of Textile Engineering.

Textiles Minor

Students with other majors often enter the textile industry. To enhance their careers the School of Textile Engineering has developed selected course offerings that could constitute an unofficial minor in textiles. Listings of recommended course sequences for minors in textiles are available in the School of Textile Engineering office.

Graduate Program

The School of Textile Engineering has a rapidly expanding graduate program leading to the Master of Science and Doctor of Philosophy degrees. Students holding an undergraduate degree in any one of several fields of science or engineering may qualify for admission. An undergraduate degree in textile engineering, textiles or textile chemistry is not a specific requirement. Each student pursues an individually structured program.

The graduate course offerings encompass advanced study and research in polymer synthesis, mechanics of fibrous structures, process dynamics, dyeing and dye synthesis, viscoelasticity, experimental design, properties of materials, polymer flow, polymer environmental stability, process control, energetics and kinetics. The School of Textile Engineering has a variety of active research programs in which students participate.

The School of Textile Engineering is housed in the Hightower Building, a four-story classroom and laboratory facility. The building contains equipment illustrating most major types of textile processing. Well equipped laboratories are also available for the chemical and physical characterization of polymers, fibers and fiber assemblies. Specialized equipment is available for fabric flammability studies, polymer environmental stability experiments, fiber-reinforced composite testing and water pollution studies. Machine shop and instrumentation facilities with full-time supporting technicians are housed within the building.

Program for Bachelor of Textile Engineering Degree

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1101-2	General Chemistry	4-3-5	4-3-5	.....
E.Gr. 1170	Visual Communication and Engineering Design I	2-3-3	.....	.....

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Phys. 2121	Particle Dynamics	.....	.....	4-3-5
Electives ³	Physical Education	0-4-1	0-4-1	0-4-1
Text. 1100	Introduction to Textile Engineering	.....	.....	3-0-3
Elective	Humanities/Social Science/Modern Language	.....	3-0-3	.....
Electives ¹		2-0-2	2-0-2	2-0-2
	Totals	13-10-16	14-7-16	14-7-16

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.S.M. 2201	Statics	3-0-3	.....	.....
E.S.M. 3201-2	Dynamics I, II	.....	3-0-3	3-0-3
Math. 2307-8	Calculus IV, V	5-0-5	5-0-5	.....
Phys. 2122-3	Electromagnetism, Optics and Modern Physics	4-3-5	4-3-5	.....
Text. 3400	Computer Applications in Textiles	.....	.....	2-3-3
Text. 2181-2	Textile Manufacturing Processes II, III	.....	0-3-1	0-3-1
Text. 4200	Fiber Science	.....	.....	3-0-3
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective ¹		.....	.....	3-0-3
	Totals	15-3-16	15-6-17	14-6-16

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Text. 4201-2	Mechanics of Fibrous Structures I, II	3-0-3	.....	3-0-3
E.S.M. 3301	Mechanics of Deformable Bodies	5-0-5	.....	.....
E.S.M. 3302	Mechanics of Materials	.....	3-0-3	.....
M.E. 3322-3	Thermodynamics	3-0-3	3-0-3	.....
I.Sy.E. 3749	Elementary Quality Control	.....	.....	3-0-3
Text. 3480-1	Textile Manufacturing Processes IV, V	0-3-1	0-3-1	.....
Text. 3484	Problems in Textile Management II	.....	.....	0-3-1
Text. 4750-1	Polymer Science and Engineering I, II	.....	3-0-3	3-0-3
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives ¹		3-0-3	3-0-3	3-0-3
	Totals	17-3-18	15-3-16	15-3-16

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Text. 4420	Analysis of Textile Materials	3-3-4	.....	.....
Text. 4203	Mechanics of Fibrous Structures III	.....	3-0-3	.....
C.E. 3053-4	Fluid Mechanics I, II	.....	3-0-3	3-0-3
E.E. 3725	Electrical Circuits and Fields	3-0-3	.....	.....
E.E. 3726	Elementary Electronics	.....	3-0-3	.....
Text. 3750	Elementary Heat and Mass Transfer	3-0-3	.....	.....

Senior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
I.Sy.E. 4725	Engineering Economy	.....	.....	3-0-3
Text. 4400	Seminar	.....	1-0-1	.....
Text. 4401	Introduction to Textile Literature	1-0-1	.....	.....
Text. 3485	Problems in Textile Management III	0-3-1	.....	.....
Text. 4481	Advanced Problems in Textile Management	.....	0-3-1	.....
Text. 4482	Product Innovation	.....	.....	0-3-1
Text. 4204 ²	Chemical Processing of Textile Materials	.....	.....	3-0-3
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives ¹		3-0-3	3-0-3	3-0-3
	Totals	16-6-18	16-3-17	15-3-16

¹Twelve hours of electives must be chosen from a list recommended by the department. Six must be humanities/social science/modern language.

²Text. 4301 can be substituted for Text. 4204.

³See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

Program for the Bachelor of Science in Textiles Degree

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1101-2	General Chemistry	4-3-5	4-3-5	.....
Engl. 1001-2-3	Analysis of Literature	3-0-3	3-0-3	3-0-3
Math. 1711-2-3	Mathematics for Management I, II, III	5-0-5	5-0-5	5-0-5

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.Gr. 1170	Introduction to Visual Communications and Engineering Design I	.....	2-3-3	.....
Text. 1100	Introduction to Textile Engineering	.....	.....	3-0-3
Electives ³	Physical Education	0-4-1	0-4-1	0-4-1
Electives ¹		2-0-2	2-0-2	2-0-2
	Total	14-7-16	16-10-19	13-4-14

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Phys. 2111-2-3	Physics	4-0-4	4-0-4	4-0-4
Engl. ² 2001-2-3	Survey of the Humanities	3-0-3	3-0-3	3-0-3
Econ. 2000-1	Economic Principles and Problems	3-0-3	3-0-3	.....
Text. 2100	Introduction to Fiber Science	3-0-3	.....	.....
Text. 2101	Yarn Processing I	.....	3-0-3	.....
Text. 3110	Woven Structures I	.....	.....	3-0-3
Text. 2180-1-2	Textile Manufacturing Processes I, II, III	0-3-1	0-3-1	0-3-1
Electives ¹		3-0-3	3-0-3	6-0-6
	Totals	16-3-17	16-3-17	16-3-17

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Text. 3120	Introduction to Textile Chemistry	3-0-3	.....	.....

Junior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Text. 3121	Structures of Organic Polymers	.....	3-3-4	.....
Text. 4300	Chemistry and Chemical Processing of Fibers and Textiles I	.....	.....	3-0-3
Text. 3112	Knit Fabrics	3-0-3	.....	.....
Text. 3113	Nonwoven Fabrics	.....	3-0-3	.....
Text. 3400	Computer Applications in Textiles	.....	.....	2-3-3
Mgt. 2000-1	Accounting I, II	3-0-3	3-0-3	.....
Mgt. 3060	Financial Management	.....	.....	3-0-3
Mgt. 3300	Marketing I	3-0-3	.....	.....
Text. 4200	Fiber Science	.....	3-0-3	.....
I.Sy.E. 3749	Elementary Quality Control	.....	.....	3-0-3
Text. 3480-1-2	Textile Manufacturing Processes IV, V, VI	0-3-1	0-3-1	0-3-1
Text. 3483-4	Problems in Textile Management I, II	0-3-1	0-3-1	.....
Electives ¹		3-0-3	3-0-3	3-0-3
	Totals	15-6-17	15-9-18	14-6-16

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Text. 4420	Analysis of Textile Materials	3-3-4	.....	.....
Text. 4400	Seminar	.....	1-0-1	.....
Text. 4401	Introduction to Textile Literature	1-0-1	.....	.....
Text. 4100	Textile Management Decision Making	.....	.....	2-3-3

Senior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Text. 4301	Chemistry and Chemical Processing of Fibers and Textiles II	3-3-4	.....	.....
Psy. 4401	Industrial Psychology	.....	.....	3-0-3
Mgt. 4200	Industrial Relations	.....	.....	3-0-3
I.Sy.E. 3015	Analysis of Production Operations	.....	4-0-4	.....
Mgt. 3150	Industrial Management Principles	.....	3-0-3	.....
Text. 3485	Problems in Textile Management III	0-3-1	.....	.....
Text. 4480	Problems in Production Supervision	0-3-1	.....	.....
Text. 4481	Advanced Problems in Textile Management	.....	0-3-1	.....
Text. 4482	Production Innovation	.....	.....	0-3-1
Electives ¹		6-0-6	6-0-6	6-0-6
	Totals	13-12-17	14-3-15	14-6-16

¹Twelve hours of electives must be chosen from a list recommended by the department. Nine must be humanities/social science/modern language electives.

²English 2004 or 2007 may be substituted for English 2003.

³See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

Program for Bachelor of Science in Textile Chemistry

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1111-2	General Chemistry	4-3-5	4-3-5	.....
Chem. 1113	Chemical Principles	.....	.....	3-3-4

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.Gr. 1170	Visual Communication and Engineering Design I	.....	.....	2-3-3
Engl. 1001-2-3	Analysis of Literature	3-0-3	3-0-3	3-0-3
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives	Modern Language or Social Science	3-0-3	3-0-3	3-0-3
Electives ⁴	Physical Education	0-4-1	0-4-1	0-4-1
Electives ¹		2-0-2	2-0-2	2-0-2
	Totals	17-7-19	17-7-19	18-10-21

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 3311-2-3	Organic Chemistry	3-0-3	3-0-3	3-0-3
Chem. 3381-2	Organic Chemistry Laboratory	.....	0-6-2	0-6-2
Math. 2307-8	Calculus IV, V	5-0-5	5-0-5	.....
Phys. 2121	Particle Dynamics	4-3-5	.....	.....
Phys. 2122	Electromagnetism	.....	4-3-5	.....
Phys. 2123	Optics and Modern Physics	.....	.....	4-3-5
Engl. 2001	Survey of the Humanities	.....	.....	3-0-3
Text. 1100	Introduction to Textile Engineering	3-0-3	.....	.....
Text. 3400	Computer Applications in Textiles	2-3-3	.....	.....
Electives ¹		.....	.....	3-0-3
	Totals	17-6-19	12-9-15	13-9-16

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 3412-3	Physical Chemistry	3-0-3	3-0-3	.....
Chem. 3481	Physical Chemistry Laboratory	.....	0-6-2	.....
Engl. 2002-3	Survey of the Humanities	3-0-3	.....	3-0-3
Biol. 4413 ²	Air and Water Pollution	3-0-3	.....	.....
Text. 4750-1	Polymer Science and Engineering I, II	.....	3-0-3	3-0-3
Text. 4200	Fiber Science	.....	3-0-3	.....
Text. 4300	Chemistry and Chemical Processing of Fibers and Textiles I	.....	.....	3-0-3
Text. 3480-1	Textile Manufacturing Processes IV, V	0-3-1	0-3-1	.....
Text. 3484	Problems in Textile Management II	.....	.....	0-3-1
Electives ¹		6-0-6	3-0-3	6-0-6
	Totals	15-3-16	12-9-15	15-3-16

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Text. 4420	Analysis of Textile Materials	3-3-4	.....	.....
Text. 4100	Textile Management Decision Making	.....	.....	2-3-3
Text. 4310 ³	Textile Instrumental Analysis	.....	.....	2-3-3
Text. 4400	Seminar	.....	1-0-1	.....
Text. 4401	Introduction to Textile Literature	1-0-1	.....	.....

Senior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Text. 4301	Chemistry and Chemical Processing of Fibers and Textiles II	3-3-4	.....	.....
Text. 4503	Science of Color	.....	3-0-3	.....
Text. 4201-2	Mechanics of Fibrous Structures I, II	3-0-3	.....	3-0-3
Text. 3485	Problems in Textile Management III	0-3-1	.....	.....
Text. 4481	Advanced Problems in Textile Management	.....	0-3-1	.....
Text. 4482	Product Innovation	.....	.....	0-3-1
Electives ¹		<u>3-0-3</u>	<u>9-0-9</u>	<u>3-0-3</u>
	Totals	13-9-16	13-3-14	10-9-13

¹Fifteen hours of electives must be chosen from a list recommended by the department. Nine hours must be humanities/social science/modern language electives.

²C.E. 4103 or 4113 may substitute for Biol. 4413

³Chem. 4211 or 4212 may substitute for Text. 4310.

⁴See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

General College

Department of Air Force Aerospace Studies

(Established in 1950)

Professor and Head of Air Force Aerospace Studies—Colonel Henry G. Hostetter; *Assistant Professor*—Major Thomas A. Barrett, Jr., Lt. Col. William A. Olsen, Captain Dallas D. Morgan, Major William J. McKechney.

General Information

Air Force Reserve Officer Training Corps (AFROTC) program is divided into two phases. The first two years constitute the General Military Course (G.M.C.) and the last two years, the Professional Officer Course (P.O.C.).

Four-Year Program

Students entering the four-year program enroll in AFROTC courses in the same manner in which they register for other undergraduate courses. A formal application is not required. Students enrolled in the G.M.C. incur no military obligation. Students must compete for entry into the P.O.C., which is normally taken during the last two years of college. Selection is based upon the results of an Air Force medical examination, the scores achieved on the Air Force Officer Qualifying Test and an interview by a board of Air Force officers. Cadets normally attend a four-week field training session conducted at a regularly established Air Force base between their sophomore and junior years. Co-op students normally attend field training after graduation. Students accepted for the P.O.C. become members of the Air Force Reserve and receive a \$100 per month tax-free subsistence allowance.

Two-Year Program

The two-year program and the last two years of the four-year program are identical in academic content. The basic requirement for entry into this program is that the student have two academic years remaining in school. This may be at the undergraduate or graduate level, or a combination of the two. Selection of two-year applicants is predicated upon the same criteria as four-year program cadets. In addition, candidates must

successfully complete a six-week field training course at an Air Force base during the summer preceding their enrollment. Applicants enter the P.O.C. upon their return to campus.

AFROTC College Scholarship Program

AFROTC college scholarships are available to qualified cadets in the two- and four-year programs. Scholarships cover tuition, matriculation, health services, student activities fees and books. All scholarship cadets also receive a \$100 per month tax-free subsistence allowance.

School of Biology

(Established in 1960)

Director—John W. Crenshaw, Jr.; *Professors*—Walter L. Bloom, Robert H. Fetner, Thomas W. Kethley, David W. Menzel (Adjunct), Hugh A. Wyckoff (Emeritus); *Associate Professors*—Edward L. Fincher, John J. Heise, Alfred W. Hoadley, N. W. Walls, Edward K. Yeagers; *Assistant Professors*—Gary L. Anderson, Arthur C. Benke, David B. Dusenbery, David M. Gillespie, Susan P. Porterfield, John R. Strange, Roger M. Wartell; *Instructors*—Roberta M. Smith, Ronald D. Snyder, G. Thomas Tibbs.

General Information

Programs of study offered by the School of Biology are designed to lead to competence in this basic science. The institute, with its strength in science and technology, provides unique opportunities for training and research in biology. The curriculum encourages program enrichment by incorporating course selections from other schools and departments.

The Bachelor of Science degree program provides for a combination of requirements and electives that ensure the attainment of a broad background in biology with sufficient flexibility to satisfy a wide spectrum of individual interests and career objectives. The undergraduate curriculum in biology is well suited to prepare students for graduate study or for medicine, dentistry or other health profession schools.

Optional courses of study are available for the undergraduate degree providing for specialization in a given area such as physiology, or for combined studies in biology and mechanics or in biology and electronics. The latter combinations lead to the undergraduate degree biomechanics option and electronics option respectively.

The School of Biology offers graduate work leading to the Master of Science degree. Programs are flexible and are designed to serve the specific needs of the student. Interdisciplinary programs involving other schools within the institute are encouraged.

Members of the faculty are actively engaged in such research fields as aerobiology, biophysics, cell physiology, mammalian physiology, developmental biology, ecology, microbiology, population genetics and radiation cytogenetics. Areas of particular strength include microbiology, physiology and radiation biology.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Biol. 1001	Orientation to Biology	.....	.....	1-0-1
Chem. 1111-2, 2113	General Chemistry	4-3-5	4-3-5	3-3-4
Engl. 1001-2-3	Introduction to Literature	3-0-3	3-0-3	3-0-3
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives ¹	Modern Language or Social Science	3-0-3	3-0-3	3-0-3
Electives ⁴	Physical Education	0-4-1	0-4-1	0-4-1
Electives ²	Free	2-0-2	2-0-2	2-0-2
	Totals	17-7-19	17-7-19	17-7-19

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Biol. 2210-1-2	Introductory Biology	4-3-5	4-3-5	4-3-5
Engl. 2001-2-3	Survey of the Humanities	3-0-3	3-0-3	3-0-3
Electives ¹	Modern Language or Social Science	3-0-3	3-0-3	3-0-3
Chem. ³ 3311-2-3	Organic Chemistry	3-0-3	3-0-3	3-0-3
Chem. 3381-2	Organic Chemistry Lab	0-6-2	.....	0-6-2
	Totals	13-9-16	13-3-14	13-9-16

¹Choice of (1) two quarters of one of the following: American history, political science, philosophy and history of science or sociology and the third quarter selected from one of the three remaining areas or (2) three quarters of modern languages in either German, French or Spanish. Three quarters of either modern language or social science are required.

²These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, then it should be scheduled beginning the first quarter the student is enrolled.

³Chem. 3511 (biochemistry) may be substituted for Chem. 3313 (organic chemistry).

⁴See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

Junior and Senior Years

The minimum total number of credit hours required for a bachelor's degree in biology is 200. In addition to the required courses of the freshman and sophomore years, the following courses are required of all candidates for the degree.

Phys.	2121-2-3	Introductory Physics (4-3-5 each)	15 hrs.
Bio.	3310	General Microbiology (3-6-5)	5 hrs.
Bio.	3320	Cell Physiology (3-3-4)	4 hrs.
Bio.	3333	Biostatistics (3-3-4)	4 hrs.
Bio.	3334	Genetics (3-3-4)	4 hrs.
Electives		Technical	48 hrs.
Electives		Free	17 hrs.
Junior and Senior Year Total			97 hrs.

Of the 71 hours of electives indicated above, 48 hours must be departmentally approved technical elective courses in biology, chemistry, mathematics, physics or engineering. At least 25 of these hours must be biology course offerings. All technical electives must be chosen in conference with a faculty adviser to provide a meaningful, interrelated group ancillary to a specific field of interest. The other 41 hours of electives include 18 hours of social sciences and 23 hours of free electives. Not more than nine hours of free electives in the junior and senior years may be advanced ROTC

School of Chemistry

(Established in 1906)

Director—J. Aaron Bertrand; *Assistant Director*—James A. Stanfield; *Regents' Professors*—Eugene C. Ashby, William H. Eberhardt, Hermann A. Flaschka; *Seydel-Woolley Professor*—Herbert O. House; *Julius Brown Professor*—Erling Grovenstein, Jr.; *Professors*—Edward M. Burgess, Drury S. Caine, III, Henry L. Edwards (Emeritus), Richard W. Fink, Charles L. Liot-

ta, George A. Miller, Thomas F. Moran, Henry M. Neumann, Robert A. Pierotti, William M. Spicer, Leon H. Zalkow, *Associate Professor*—Raymond F. Borkman, Ronald H. Felton, Sidney L. Gordon, Harold R. Hunt, James C. Powers, Donald J. Royer, Peter B. Sherry, Peter E. Sturrock, Allan C. Topp; *Assistant Professors*—William F. Fisher, Sheldon May, Nai Teng Yu.

General Information

Included in the school are courses in chemistry required for various engineering curricula, a curriculum leading to the degree of Bachelor of Science in Chemistry, graduate courses and research leading to the degree of Master of Science in Chemistry and Master of Science in Nuclear Science and graduate courses and research leading to the degree Doctor of Philosophy in Chemistry.

The degree Bachelor of Science in Chemistry will be awarded upon the completion of the following prescribed courses and 62 quarter hours of elective work. A student must have had the prerequisites for any course he elects.

A prerequisite for senior courses is a minimum grade point average of 2.0 in the following courses: Chem. 3311, 3312, 3313, 3381, 3382, 3383, 3411, 3412, 3413, 3481 and 3491.

The great number of free elective hours in the chemistry curriculum permits concentrated studies in pre-medical and pre-dental requirements, minor options in geochemistry and T-4 certification in association with Georgia State University. Free electives may also include options in written and oral communication, business and management, information and computer science, biochemistry and environmental chemistry.

The School of Chemistry also offers graduate programs for both the master's and doctoral degrees in the fields of analytical, inorganic, nuclear, organic and physical chemistry. In addition, courses are offered and considerable research is oriented toward biochemistry.

Active research fields include biophysical chemistry, brillouin spectra, carbanion chemistry, chemistry of natural products, electron-transfer reactions, enzyme chemistry, instrumental methods of analysis, mass spectrometry, mechanisms of organic, biological and inorganic reactions, molecular spectra and molecular structure, nuclear chemistry, nuclear magnetic resonance, organic synthesis, organometallic chemistry, photochemistry, quantum mechanics, radioactive exchange reactions, structures of complex inorganic compounds, surface phenomena, theoretical chemistry and thermodynamic properties.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1111-2	General Chemistry	4-3-5	4-3-5	.....
Chem. 2113	Chemistry Principles	.....	.....	3-3-4
Math. 1307-8-9	Calculus	5-0-5	5-0-5	5-0-5
Engl. 1001-2-3	Introduction to Literature	3-0-3	3-0-3	3-0-3
Elective	Elementary German ¹ or Social Science	3-0-3	3-0-3	3-0-3
Elective ⁶	Physical Education	0-4-1	0-4-1	0-4-1
Electives ²	Free	2-0-2	2-0-2	2-0-2
	Totals	17-7-19	17-7-19	16-7-18

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 3311-2-3	Organic Chemistry	3-0-3	3-0-3	3-0-3
Chem. 3381-2-3	Organic Chemistry Lab	0-6-2	0-6-2	0-6-2
Math. 2307	Calculus	5-0-5	.....	.....
Math. 2308	Calculus and Linear Algebra	.....	5-0-5	.....
Phys. 2121-2-3	Physics	4-3-5	4-3-5	4-3-5
Electives ³	Free	.....	.....	6-0-6
	Totals	12-9-15	12-9-15	13-9-16

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 3411-2-3	Physical Chemistry	3-0-3	3-0-3	3-0-3
Chem. 3481	Physical Chemistry Lab	.....	0-6-2	.....
Chem. 3111-2	Inorganic Chemistry	.....	4-0-4	4-0-4
Chem. 4211	Instrumental Analysis I	3-6-5	.....	.....

Junior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Engl. 2001-2-3	Survey of the Humanities	3-0-3	3-0-3	3-0-3
Electives ³	Free	5-0-5	5-0-5	6-0-6
	Totals	14-6-16	15-6-17	16-0-16

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 4401	Physical Chemistry	3-0-3	.....	.....
Chem. 3491	Physical Chemistry Lab	0-6-2	.....	.....
Chem. 4341	Applied Spectroscopy	.....	3-0-3	.....
Chem. ⁴ 4212	Instrumental Analysis II	.....	3-6-5	.....
Electives ³	Free	9-0-9	6-0-6	10-0-10
Electives ⁵	Chemistry	.....	3-0-3	4-0-4
	Totals	15-6-17	15-6-17	14-0-14

¹The School of Chemistry recommends that German be taken in the freshman year. However, social science may be taken in the freshman year and German taken later.

²These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled.

³Electives, free: Of the total free electives in the chemistry curriculum, at least eighteen hours of social science, selected from the General College listing in "Information for Undergraduate Students," must be taken.

⁴May be taken in the junior year.

⁵A total of ten quarter hours in elective chemistry courses are required of which a minimum of four hours and a maximum of six hours must be from laboratory electives. These laboratory electives may consist of:

- Two laboratory courses, 0-6-2 each.
- One laboratory course, 0-6-2, and Chem. 4901, 4902, or
- Chem. 4901, 4902, 4903.

Options b and c must have the approval of the department.

Chemistry electives may consist of those chemistry courses numbered 4xxx, 6xxx, 7xxx or other courses approved by the department; however Chem. 4701 and 4741 may not be offered as chemistry electives.

Registration for courses 6xxx and above must have departmental and graduate division approval.

⁶See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

Department of English

Department Head and Professor—David B. Comer, III; *Associate Head and Professor*—Tom F. Almon; *Professors*—Milton Chaikin, James B. Haman, Samuel C. Ketchin, L. Hugh Moore, William B. Mullen, Karl M. Murphy, Glenn W. Rainey, Larry J. Rubin, Ralph R. Spillman, Andrew J. Walker (Emeritus), James D. Young; *Associate Professors*—James J. Bynum, Irving F. Foote, A. Frank Hamrick, Annibel Jenkins, Helen H. Naugle, John P. O'Neill, Esta K. Seaton, James P. Smith, William R. Spruill; *Assistant Professors*—Richard B. Bell, Ralph Bergamo, Edith H. Blinksilver, May C. Brown, Wister J. Cook, Richard J. Corbin, Elizabeth Evans, R. Dwayne Howell, Sarah E. Jackson, John M. Kaman, Robert L. Meredith, Matthew C. O'Brien, James E. Radford, Maxine T. Turner; *Instructors*—Betsy P. Graham, Donald D. Russ, Richard J. Singletary; *Lecturer*—R. Lee Alpaugh.

General Information

At the freshman-sophomore level the Department of English offers a unified six-quarter sequence of courses devoted to the study and appreciation of literature and to intensive practice in composition. The freshman courses stress the relationship between content and literary form; the sophomore courses emphasize the humanistic values of literature in Western culture. The practice in composition makes use of the literature for subject matter and stresses logical thinking, proper organization of material, effective use of evidence and clarity and precision of expression.

The department also offers elective courses in both written and oral communication and in literature and language. The courses in communication include practical training in public speaking and in various kinds of writing that are useful in science, business and industry. The electives in literature cover a variety of approaches: major writers since the Renaissance studied in the scientific and philosophical context of their times, types of literary form, thematic approaches and seminars in individual writers. Credit in drama is granted for participation in productions of DramaTech, the student drama club.

A special two-year program in the English language, composition and American literature is offered for students whose native language is other than English. Four of these courses—English 1033, 2031-2-3—are classified as courses in the humanities.

Students who score sufficiently high on the Advanced Placement Examination administered by the College Entrance Examination Board are exempt from certain freshman-sophomore

courses. A number of students in the College of Engineering whose curricula do not require English 1001-2-3 and whose scores on the College Board SAT-Verbal and the English Achievement examinations are sufficiently high are given the option of waiving one or more of the freshman courses as prerequisites to enrollment in the upper-level courses offered by the department.

School of Geophysical Sciences

(Established in 1970)

Director and Professor—Charles E. Weaver; *Professor*—David W. Menzel (Adjunct); *Associate Professors*—Kevin C. Beck, L. Timothy Long, Charles O. Pollard, Jr., J. Helmut Reuter, J. Marion Wampler, Herbert L. Windom; *Assistant Professors*—James L. Harding (Adjunct), Robert P. Lowell, G. Lafayette Maynard; *Supporting Faculty*—R. A. Young, W. V. Conn.

General Information

The School of Geophysical Sciences offers graduate study programs for those interested in understanding the earth and man's physical environment at its surface. The programs lead to the degrees Master of Science in Geophysical Sciences and Doctor of Philosophy. The term geophysical sciences is used in the broadest sense to include both the physics and chemistry of the earth, its waters and atmosphere. Special emphasis is given to studying man's modification of his environment. Through joint research with engineers, students can relate their basic scientific studies to the solution of environmental problems.

Persons with an undergraduate degree in geology, chemistry, physics, mathematics, biology or engineering may be admitted to the graduate program. Individual programs of study will be tailored to each student's background and interests.

Present areas of specialization include geophysics, geochemistry, mineralogy, sedimentology, marine geology and environmental geology. Interdisciplinary studies can be carried out in such areas as crystallography (crystal physics), geohydrology, engineering geology, nuclear science and engineering, organic geochemistry and space geophysics.

Research and study in oceanography is conducted in cooperation with the staff of the Skidaway Institute of Oceanography at Savannah, Georgia. Many of the staff members from both institutions hold joint appointments. Students desiring to do so may spend a significant portion of their time at Skidaway.

Undergraduate Program

The geophysical sciences are multidisciplinary with a strong dependence on the basic physical sciences and mathematics, therefore, the undergraduate program in geophysical sciences has been developed within undergraduate programs of other Georgia Tech schools.

A geochemistry option is available in the undergraduate curriculum in chemistry; a geophysics option in the undergraduate curriculum in physics. These options involve substitution of courses in geology for some of the directed and free electives in these curricula.

Undergraduate students in other majors may develop a substantial background in geology by completing the requirements for a minor in geophysical sciences within the elective structure of their own degree program. Such a minor would be important, for example, to a student in civil engineering who is interested in engineering geology.

Students who find they have a strong interest in geology may elect to pursue an undesignated baccalaureate degree under the direction of the School of Geophysical Sciences faculty. The curriculum for such a student would be similar to an existing designated baccalaureate program (as in chemistry, physics or civil engineering) but would allow greater latitude in selection of courses. Detailed listings of the courses to be scheduled in the geochemistry and geophysics options, and in the geophysical sciences minor, are available in the School of Geophysical Sciences office.

Master of Science in Geophysical Sciences

Graduate study will be tailored to the background and interests of each master's candidate. A student frequently will be admitted without sufficient background in the sciences or mathematics to pursue some of the graduate courses important to his interests, therefore, some remedial work without graduate credit may be required.

A special field study requirement must be met before admission to candidacy for the master's in geophysical sciences. This requirement may be met by completion of an appropriate field course.

Doctoral Program

Persons with a strong background in the basic sciences and mathematics, who show a capability for high achievement in

research in the geophysical sciences, may enter a program of study leading to the doctoral degree. A wide range of individual programs is available, owing to the multidisciplinary nature of the geophysical sciences. A special field study requirement, more extensive than that required for the master's, must be met before admission to candidacy for the doctoral program.

School of Information and Computer Science

(Established in 1963)

Director—Vladimir Slamecka; *Professors*—Lucio Chiaraviglio, James Gough, Jr., Edward G. Roberts, Vladimir Slamecka, James W. Sweeney, Miroslav Valach, Pranas Zunde; *Associate Professors*—Robert B. Cooper, Philip J. Siegmann, T. C. Ting; *Associate Professor—Librarian*—Frances E. Kaiser; *Assistant Professors*—Albert N. Badre, John J. Goda, Jr., William I. Grosky, Michael D. Kelly, David E. Rogers, Fred R. Sias, Jr. (Adjunct), Robert M. Siegmann; *Instructor*—Robert I. Winner; *Lecturer*—John M. Gwynn, Jr.

General Information

The goal of the information, computer and systems sciences is to enhance the problem-solving ability of man's mind by designing information processing automata and systems and delegating to them some of the functions of the human mind. During the last decade the use of computers has become indispensable in science, engineering, management, health care, education and other advanced professions. Many believe that in the near future information processing will become the nation's largest industry, that its disciplines will be centrally important in both science and society.

Georgia Tech's School of Information and Computer Science reflects this growth and potential. Established in 1963, with the sponsorship of the National Science Foundation, it was the world's first academic program in information science. Today the school is one of the largest graduate departments of the institute, and is among the largest computer science schools in the United States. It offers the bachelor's, master's and doctoral degrees in computer, information and systems sciences for professional and research careers in many areas of specialization. Of particular note is the school's degree program in biomedical information processing, offered jointly with the Emory University School of Medicine. In addition to its degree programs, the school also

offers carefully designed computing course sequences for students in other majors.

I.C.S. students have free access to the school's extensive computer laboratory, which includes three computer systems (a large time-shared Burroughs B-5700, a PDP 11/45 and a PDP 8/I) and a wide array of special information processing devices. Other computing resources available to students of the school are the UNIVAC 1108 computer in the Georgia Tech Computer Center and an IBM 360/50 computer by special arrangement with the Atlanta Public Schools.

Details of the academic and research programs of the school are described in brochures available upon request.

Undergraduate Program

The undergraduate program, established in 1972, leads to the designated degree of Bachelor of Science in Information and Computer Science. It provides comprehensive education in the information, computer and systems sciences and professions hospitable to multi-disciplinary objectives. The program has two primary directions. The first is the acquisition of marketable knowledge and skills for professional careers in computer systems design, programming systems and languages, numeric computation, natural language processing, information systems design (for management, health care, education, etc.), and modeling and simulation of complex systems. The second direction prepares students for theory-oriented graduate work in computer science, information science, systems science, artificial intelligence, logic or linguistics.

A total of 194 credit hours are required for graduation. The 54 hours of electives include up to 24 hours of course work in one of the areas listed above.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. ¹ 1101-2	General Chemistry	4-3-5	4-3-5	.....
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Engl. 1001-2-3	Analysis of Literature	3-0-3	3-0-3	3-0-3
Electives ⁴	Physical Education	0-4-1	0-4-1	0-4-1
I.C.S. 1100	Information, Computers, Systems: An Introduction	2-3-3	.....	.....

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
I.C.S. 1110	Reasoning and Computation	.....	.....	3-0-3
I.C.S. 1400	Introduction to Algorithms and Computing	.....	.....	2-3-3
Electives ²		2-0-2	2-0-2	2-0-2
	Totals	16-10-19	14-7-16	15-7-17

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Phys. 2121	Particle Dynamics	4-3-5	.....	.....
Phys. 2122	Electromagnetism	.....	4-3-5	.....
Phys. 2123	Optics and Modern Physics	.....	.....	4-3-5
Math. 2307	Calculus IV	5-0-5	.....	.....
Math. 2308	Calculus V	.....	5-0-5	.....
Math. 2020	Introduction to Set-Theoretic Concepts	.....	.....	3-0-3
Ling. 3003	Introduction to Structural Linguistics II	.....	.....	3-0-3
Psy. 3303-4	General Psychology A, B	.....	3-0-3	3-0-3
I.C.S. 2400	Computer Programming	2-3-3	.....	.....
I.C.S. 2600	Computer Organization and Programming	.....	3-0-3	.....
I.C.S. 2250	Technical Information Resources	1-0-1	.....	.....
Electives	Humanities/Social Science/Modern Languages	3-0-3	.....	3-0-3
	Totals	15-6-17	15-3-16	16-3-17

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Math. 3110	Introduction to Higher Algebra	3-0-3	.....	.....
Econ. 2000-1	Principles of Economics	3-0-3	3-0-3	.....
Ling. 4002	Current Developments in Linguistics	3-0-3	.....	.....
Math. 3215	Problems in Probability and Statistics	.....	5-0-5	.....
I.Sy.E. 4000	Introduction to Systems Theory	.....	.....	3-0-3
I.C.S. 3113	Information Structures and Processes	3-0-3	.....	.....
I.C.S. 3150	Introduction to Mathematical Logic	.....	3-0-3	.....
I.C.S. 3600-1	Computer Systems I, II	.....	3-0-3	3-0-3
I.C.S. 4610	Logic Design and Switching Theory	.....	.....	3-0-3
Electives ³		3-0-3	3-0-3	6-0-6
	Totals	15-0-15	17-0-17	15-0-15

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
I.C.S. 4300	Information Systems	3-0-3	.....	.....
I.C.S. 4120-1	Introduction to Information Processes I, II	3-0-3	3-0-3	.....
I.C.S. 4800	Selected Topics in I.C.S.	.....	.....	3-0-3
Electives ³		9-0-9	12-0-12	12-0-12
	Totals	15-0-15	15-0-15	15-0-15

¹With the consent of the school, these courses may be substituted by other empirical science courses relevant to the student's program.

²Free elective courses, to be taken at any time during the course of study. If basic

ROTC is selected to satisfy these six credit hours, it should be scheduled beginning the first quarter of the freshman year.

³Electives in the junior and senior years will include up to 24 credit hours in one of several areas of specialization recommended and approved by the School of Information and Computer Science.

⁴See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women. A maximum of three credit hours of physical education may be applied toward the undergraduate degree.

Professional Graduate Program

The objective of this one-year graduate program is to offer career education terminating with the degree Master of Science in Information and Computer Science. The professional program is designed primarily for persons holding degrees in quantitative fields other than computer science such as mathematics, the physical and natural sciences, engineering or the medical sciences. Graduates of this program qualify for senior technical and management careers in the information processing industry and for appropriate positions in government, health care, education and the military.

To earn the master's degree, students must complete at least 50 quarter hours, of which a minimum of 35 must be in courses at the 6000-8000 level. In addition, students must include I.C.S. 3600 and I.C.S. 3601 (Computer Systems I and II) as part of their approved program of study unless they have previously taken courses which cover this material. A master's thesis is not required; qualified students may, however, request to write a thesis in lieu of 17 credit hours of graduate course work. The four-quarter program begins in the fall quarter, and its flexible curriculum draws on over 30 graduate-level courses in applied information, computer science and systems science. Typical curricula in this program include courses in systems design, computer software, computer systems, information processing applications, management science, operations research, numerical analysis, industrial psychology and the social sciences.

Students applying for admission to the professional master's degree program must have earned a bachelor's degree from an accredited institution. While the undergraduate major is not specified, the prospective student's preparation should include substantial work in mathematics, at least through calculus, differential equations, set theory and introductory probability and statistics. Computing competence of the entering students should include higher level and assembly language programming, data structures and knowledge of searching and sorting algorithms.

Students having a weaker background are expected to enter the school in the preceding summer quarter (or earlier) to take the coursework necessary to meet admission requirements.

Doctoral Program

The doctoral program in the School of Information and Computer Science prepares exceptionally qualified individuals for research, academic and policy-level management careers. The degree of Doctor of Philosophy is awarded by the Georgia Institute of Technology for independently conducting an original study resulting in a significant contribution to the discipline's body of knowledge, or in innovative applications of existing knowledge that have an important impact on the field.

The doctoral program requires approximately three years. The first year of residence is devoted to the student's formal preparation in the foundations of the discipline and its branches, his demonstration of creative problem solving and his commitment to one of the major areas of the discipline as his research domain. The second phase of the doctoral program stresses continued study and guided research leading to the formulation of a thesis project. Thesis research and the dissertation defense complete the doctoral program.

The faculty is prepared to guide doctoral research in the theory of information, information processes and information measures, systems theory, modeling and simulation of complex systems, metatheory of computer science including logic, automata theory, formal languages and computational complexity, theory of computer systems including design and evaluation, human and social information processes including man-machine communication and natural language linguistics.

Students applying for admission to the doctoral program should offer evidence of exceptional scholastic ability, intellectual creativity and research motivation. Preferable undergraduate preparation includes computer science, mathematics, logic or other disciplines of science and engineering that encourage mathematical formalisms and abstract thought. The students are assumed to be competent in the use of computers.

Graduate Programs in Biomedical Information and Computer Science

In 1972, the Georgia Institute of Technology introduced pioneering graduate-degree programs in biomedical information processing, intended for persons seeking interdisciplinary careers in health care and medicine. The programs, which strive

for a pedagogic integration of information/computer/systems science with medicine, are offered jointly by the School of Information and Computer Science and the Emory University School of Medicine with support of the National Institutes of Health. They lead to the degree Master of Science in Information and Computer Science and Doctor of Philosophy, both awarded by the Georgia Institute of Technology.

In format, the two degree programs parallel the regular graduate programs of the School of Information and Computer Science. The professional, terminal master's program emphasizes the engineering design of advanced information processing applications and systems in health care. The doctoral program stresses research in the areas of information, computer and systems science relevant to biomedicine and health care. The curricula of these programs include substantial course work and internships at the Emory University School of Medicine and its clinical laboratories, affiliated hospitals and libraries. Detailed information concerning courses at Emory may be obtained from the School of Information and Computer Science office.

These programs should prove attractive to two groups of persons seeking professional or research careers in biomedical information processing such as recent college graduates in the natural or premedical sciences and engineering and persons holding advanced degrees in medicine. As a minimum, applicants for admission must have earned a bachelor's degree from an accredited institution and should show evidence of their ability and motivation to pursue advanced work in biomedical information and computer science. While the undergraduate major is not specified, all applicants seeking admission to these programs should have preparation in mathematics and in the use of computers.

The degree requirements and standards of the graduate programs in biomedical information and computer science are identical to those of the regular graduate programs of the School of Information and Computer Science.

Elective Mini-Curricula and Minors

Computing competence is rapidly becoming an indispensable skill for all learned professions; consequently, quality education in science, engineering and management increasingly emphasizes formal instruction in computing. The School of Information and Computer Science offers all Georgia Tech students, regardless of major, elective course sequences in computing specifically designed to support the objectives of their future professions.

Four elective mini-curricula are offered for undergraduate students: computing for science and engineering, computing for industrial management, computer systems and information systems.

The core of these mini-curricula consists of three courses which emphasize digital computer organization, computer programming, data structures and information processing (I.C.S. 1700, I.C.S. 2700 and I.C.S. 3113).

The first two mini-curricula serve students interested in the application of information processing and computing techniques to their respective field of knowledge or professions, the last two should appeal to students having deeper interest in applied information and computer science and those who may be leaning towards graduate work in this field. Detailed course schedules are available from the School of Information and Computer Science office.

Information, computer and systems science is an appropriate minor field of study for the doctoral students of the institute. Graduate students majoring in other departments of the institute are encouraged to formulate, in consultation with their advisers and I.C.S. faculty, programs of study that include formal training in computing tailored to their educational objectives.

School of Mathematics

(Established in 1952)

Director and Professor—John D. Neff; *Associate Director and Professor*—George C. Caldwell*; *Assistant Director and Associate Professor*—George L. Cain, Jr.; *Assistant Director and Assistant Professor*—Richard A. Duke; *Regents' Professor*—Marvin B. Sledd; *Professors*—Albert T. Bharucha-Reid, John C. Currie, Bertram M. Drucker, Eric R. Immel, William J. Kammerer, Robert H. Kasriel, M. Zuhair Nashed, James W. Walker; *Associate Professors*—Johan G. F. Belinfante, James C. Brooks, Samuel H. Coleman, Donald M. Friedlen, Jamie J. Goode, James V. Herod, Dar-Veig Ho, Roger D. Johnson, John P. Line, Gunter H. Meyer, Albert L. Mullikin, James M. Osborn, Daniel A. Robinson, William R. Smythe, Jr., Frank W. Stallard, Michael P. Stallybrass, C. Robert Swenson, Joe W. Wray; *Assistant Professors*—Nathaniel Chafee, Stephen G. Demko, Arthur E. Fulton**, Harvey J. Iglarsh, Robert P. Kertz, David L. Morgan, E. Juanita Pitts, Ronald W. Shonkwiler, William Sikonia, M. Carl Spruill, Guy A. York; *Instructors*—Robert R. Appleson, Catherine C. Aust, Stephen E. Scherer,

Alan D. Sloan, Raymond D. Terry; *Lecturers*—William P. McKibben, Dickenson M. Taliaferro.

* deceased October 26, 1973

**deceased August 1, 1973

General Information

Mathematics provides the common language of science and is thus of fundamental importance in virtually all areas of science and technology. The School of Mathematics offers a wide range of service courses for students of science, engineering and management. It also offers work leading to the bachelor's, master's and doctoral degrees in mathematics. In addition to preparing a student to be a professional mathematician, an education in mathematics can provide an excellent preprofessional preparation or foundation for further work in other mathematically-oriented disciplines.

Undergraduate Program

No more than six hours of physical education course work may be counted toward graduation.

In addition to the institutional requirement of at least a 2.0 grade point average for the entire academic program, the School of Mathematics requires a minimum grade of C be received in each mathematics course designated by number in the program. The twenty hours of mathematics course work described in items four and five of the junior and senior year must be completed with at least a 2.0 grade point average.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Engl. 1001-2-3	Literature	3-0-3	3-0-3	3-0-3
Elective	Chem. 1101-2 or 1111-2, General Chemistry	4-3-5	4-3-5	.....
Phys. 2121	Particle Dynamics	.....	.....	4-3-5
Electives	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective ¹	Physical Education	0-4-1	0-4-1	0-4-1
Totals		17	17	17

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Math. 2307-8	Calculus IV, V	5-0-5	5-0-5	.....
Math. 3308	Differential Equations	.....	.....	5-0-5
Elective	I.C.S. 1700 or E.E. 1010, Introduction to Computer Pro- gramming	2-3-3	.....	.....
Math. 3110	Introduction to Higher Algebra	.....	3-0-3	.....
Math. 3215	Probability and Statistics	.....	.....	5-0-5
Phys. 2122	Electromagnetism	4-3-5	.....	.....
Phys. 2123	Optics, Modern Physics	.....	4-3-5	.....
Elective	Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective	Free	.....	.....	3-0-3
Totals		16	16	16

Junior and Senior Years

1. Math. 4110, 4120, 4311, 4312, 4313, 4321, 23 hours
2. Phys. 3121 5 hours
3. Course work at or above the 3000 level in a degree
granting school other than mathematics 6 hours
4. Mathematics courses in at least two of the areas
probability, statistics or stochastic processes;
differential equations; numerical analysis or
optimization; mathematical models. These courses
must be at or above the 4000 level and must include
at least one sequence 10 hours
5. Mathematics courses at or above the 4000 level,
including at least one sequence 10 hours
6. Humanities and social science courses. The degree
program must include either a year sequence in a
modern language, or nine hours of English beyond Eng.
1001-2-3 24 hours

7. Free electives	19 hours
Total	97 hours

*See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

Graduate Programs

A program of study for the master's degree should include Math. 6310, 6320, 6330 and at least one of the following courses: Math. 6510, 6520 or 6530. In addition, six hours of course work at the 3000 level or higher should be taken outside of the School of Mathematics. The program should also include either a thesis (17 hours) and seven additional hours of course work at the 4000 level or higher or 24 hours of course work at the 4000 level or higher, including nine hours of concentration in some field of mathematics, three hours in numerical analysis and three hours in probability, statistics or stochastic processes (provided that the student has not previously had such training) and a sufficient number of hours at the 6000 level or higher to insure that the program includes a total of at least 35 hours at this level.

A grade point average of at least 2.7 in the mathematics courses in the program of study and a grade of C or better in each mathematics course in the program of study are required.

Before admission to candidacy for the master's degree, each student must pass an oral comprehensive examination.

Most applicants holding the bachelor's degree are urged to enter the master's degree program before seeking admission to the doctoral program.

Prospective candidates for the doctoral degree are required to complete 77 hours of course work beyond the undergraduate degree. Of these 77 hours at least 30 hours must be taken in certain specified areas of mathematics including those subjects required for all students in the master's degree program. Fifteen of the 77 hours must be taken outside the School of Mathematics and constitute the student's minor field of study.

A grade of C or better is required in each course to be counted toward the total of 77 credit hours and a grade point average of 2.7 is required in the minor courses.

Prior to admission to candidacy for the doctoral degree, each student must pass comprehensive examinations in each of four areas of mathematics selected in part by the student.

Doctoral candidates must demonstrate a reading knowledge of

two languages chosen from French, German and Russian, and satisfy the institute requirements with respect to the dissertation and final oral examination.

Department of Military Science

(Established in 1917)

Professor of Military Science—Colonel Andrew J. Waldrop; *Assistant Professors*—Lieutenant Colonels Gus S. Plagianis, Marion F. Meador, Edgar R. Allingham; Majors Charles Anderson, Jr., Captains Lonnie G. Hartley, James L. Singleton.

General Information

The purpose of the U.S. Army's Senior Reserve Officers' Training Corps (ROTC) is to select for commissioning in the reserve or regular components of the Army of the United States college students who receive a baccalaureate or higher degree and successfully complete a program of instruction in military science. The Department of Military Science at the Georgia Institute of Technology offers instruction in the two- and four-year programs. The four-year program consists of the basic and advanced courses, each of two years duration. The two-year program is open to both undergraduate and graduate students who wish to take the advanced course, and who attend a six week basic summer camp in lieu of the basic course prior to enrollment in the advanced course.

Students who have demonstrated a high leadership potential and meet the following requirements may be selected by the professor of military science for enrollment in the advanced course: (1) complete the basic course or basic summer camp, (2) pass the ROTC Qualifying Examination or equivalent, (3) pass the officer physical examination, (4) normally have six academic quarters remaining, (5) be recommended by a board of officers and (6) if selected, enlist in the enlisted reserves. When selected in the advanced course, the student must sign a written contract agreeing to meet certain requirements as to completion of the course including one summer training camp and acceptance of a commission if tendered. While enrolled in the advanced course, students receive a subsistence allowance of \$100 a month, which is nontaxable.

Reserve officers serve either three to six months or two years on active duty. Educational delays to pursue a graduate degree may be granted on application depending upon the needs of the service. ROTC graduates who meet special requirements may apply for a regular Army appointment.

The Basic Course Curriculum

The basic course consists of six military science (M.S.) courses which are normally taken in the following sequence.

<i>Course</i>	<i>Title</i>	<i>Credit Hrs.</i>
M.S. 1100	Orientation: The Military Role in Perspective (1-1-1)	1
M.S. 1200	Terrain Analysis and Land Navigation (1-1-1)	1
M.S. 1040	Leadership Development (0-1-0)	0
M.S. 2200	Seminar In Communications and Instructional Methods (2-1-2)	2
M.S. 2300	Military History (3-1-3)	3
M.S. 2100	Analysis of Command and Leadership (2-1-2)	2
Total		9 ¹

¹A total of six credit hours of basic ROTC courses may be applied toward a degree.

The Advanced Course Curriculum

The advanced course consists of six military science courses and one of three elective political science courses (Political Science 3203, 3204 or 3205). These are three credit hour courses presented by the Department of Social Sciences, and may be applied toward the humanities and social science requirements in all curricula leading to an undergraduate degree. Four of the military science courses constitute a core curriculum to be completed by all students enrolled in the advanced course. The remaining two military science courses are selected from the branch material course offering, and will be appropriate to the branch in which the commission is sought.

<i>Course</i>	<i>Title</i>	<i>Credit Hrs.</i>
M.S. 3100	Tactical Decision Making (3-1-3)	3
M.S. 3040	Leadership Development (0-1-0)	0
M.S. 4100	Military Administrative Operations (2-1-2)	2
M.S. 4040	Leadership Development (0-1-0)	0
Two Branch Material Courses (3-1-3 each)		6
Total		11 ²

²A Total of nine credit hours of advanced ROTC courses may be applied toward a degree.

Department Of Modern Languages

(Established in 1904)

Department Head—James D. Wright; *Professor Emeritus*—Joseph A. Campoamor; *Professors*—George F. Walker, Louis J. Zahn; *Associate Professor*—Richard L. Hawkey; *Assistant Professors*—Charles I. Gale, Tatjana Gregory, William W. Johnson, Theodor Langenbruch, Maria S. Venable, Roy O. Wyatt; *Instructor*—Ann C. Griffin.

General Information

The Department of Modern Languages seeks to give the student sufficient mastery of a foreign language to enable him to read and understand with reasonable facility the scientific and technical literature of that language. Further, it seeks to inform the student, through the medium of the foreign language, of the civilization and literature of the countries where that language is spoken. A student taking a language in which he has two or more years of high school credit or the equivalent is encouraged to register initially for a course not lower in number than 2001 in that language. However, if such a student is convinced that his knowledge of the language in question is inadequate for successful participation in this 2000 series course, he may register for any less advanced course available in the same language at his level of preparation. Beginning with that less advanced course he may then take, for full credit toward graduation, the entire complement of language courses approved for his program of study. A student who elects to take courses in his native language must schedule, as his first course, one not lower in number than Fren. 4001, Ger. 2011, Russ. 3001 or Span. 3007. Otherwise, the student in either of these situations may schedule the beginning courses of another language.

A student may take any course for which he has the prerequisites. Credit will be given on a quarterly basis, as specified in the catalog description, but students are urged to plan at least a three-quarter sequence in a language to achieve a minimum level of proficiency.

The enrollment in German is larger than that in any of the other languages, and all three regular elementary German courses (Ger. 1001, 1002, 1003) are normally available each quarter. Consequently, students such as co-ops, who are enrolled only every other quarter, can easily complete the first year of their language study in German but might do so only with great loss of time in the other languages.

During freshman orientation placement examinations are available in French, German and Spanish for students who wish to determine their proper course level. Students whose high schools provide such examinations are encouraged to have the results of those examinations sent to the department well before their registration at Georgia Tech.

All programs of study leading to undergraduate degrees require the completion of 18 quarter hours each in the humanities and in the social sciences. Reference to "Information for Undergraduate Students" will indicate which courses taught by the Department of Modern Languages satisfy this requirement for each college.

Any of the five series of courses, French, German, Russian, Spanish and Linguistics 4075-6-7, may be taken under various programs of study. Any of these series may also be taken in satisfaction of the foreign language requirement of the graduate division. Reference to "Information for Graduate Students" will provide full detail.

With the approval of the student's major department, any course offered by the Department of Modern Languages may be taken on a pass/fail basis.

College Credit for High School Study

Those students who have two or more years of high school credit (or the equivalent) in a language offered by the Department of Modern Languages at Georgia Tech, who do not speak the language in question as a native language, who do not have college credit anywhere for the 1000 level series of courses in that language and who complete, as their first foreign language course series taken at Georgia Tech, a 2000, 3000 or 4000 level series of three courses (in Russian, two courses) in the same language with an average grade of at least C are automatically granted nine quarter hours of Georgia Tech elective credit for the 1000 level series in that language (in Russian, 12 quarter hours).¹

The nine or 12 quarter hours of credit for the 1000 level series are not applicable toward the above mentioned 36 hour social science and humanities requirement; credit for the 2000, 3000 or 4000 level series is applicable toward this requirement.

Graduate Language Requirements

The Department of Modern Languages currently serves the institute by meeting the needs of all Georgia Tech students for

¹In German the 2000 level series must be German 2001-2-3.

training in foreign languages and by administering, during each quarter of the regular academic year, the foreign language examinations that are among the options for satisfying the foreign language requirement of the graduate division. The training is available to all undergraduate students and to all graduate students through the regular series of courses in the various disciplines offered by the department. It is also available to all graduate students, to all upper divisional undergraduates, and — with the consent of the department — to exceptional lower divisional undergraduates, through the following five series of courses:

- Fren. 4075-6-7 — Intensive Readings in French,
- Ger. 4075-6-7 — Intensive Readings in German,
- Russ. 4075-6-7 — Intensive Readings in Russian,
- Span. 4075-6-7 — Intensive Readings in Spanish and
- Ling. 4075-6-7 — Comparative Analysis of Major European Languages.

These courses, although developed in response to a revision of the foreign language requirement of the graduate division, are undergraduate courses.

English for Foreign Students

The department also serves the graduate division by providing instruction in English for international students whose knowledge of English is inadequate for the study required of them. This instruction is made available partly through programs in intensive English for international students (intermediate and advanced levels under the auspices of the Department of Continuing Education). Prerequisite: two years of high school English or equivalent. Courses in grammar, pronunciation, sentence patterns, reading, theme writing and group and individual instruction in the language laboratory are also available. These intensive courses (20-25 hours per week) are usually offered during the summer quarter only.

For further information write the Department of Continuing Education, Georgia Institute of Technology, Atlanta, Georgia 30332.

Department of Music

Department Chairman and Director of Bands—Ben Logan Sisk;
Assistant Professor and Director of Glee Clubs—Jerry L. Black;
Assistant Director of Bands—C. Lloyd Tarpley.

General Information

Musical activities at Georgia Tech are taking an increasingly important place in the school, and courses are offered for academic credit to band and glee club participants. At least 36 credit hours of humanities and social sciences must be included in all curricula leading to an undergraduate degree. Certain courses taught by the Department of Music can be used toward satisfying the humanities division of this requirement.

The band is nationally known through television performances at both bowl and regular season football games. During the winter and spring quarters, the band functions as a symphonic organization doing considerable sight reading as well as performing quality band literature.

The glee club, with a history of several trips abroad and two appearances on the Ed Sullivan Show, annually performs at a number of colleges in the Southeast and in numerous local concerts. A concert tour through nearby states is generally taken between the winter and spring quarters.

Department Of Naval Science

(Established in 1926)

Commanding Officer and Professor of Naval Science — Captain Don M. Sullivan, USN; *Assistant Professors* — Major Ronald L. Bub, USMC; Lieutenant Leon C. Green, USN; Lieutenant Paul R. Morin, USN; Lieutenant Richard K. Jackson, USN.

General Information

Naval ROTC students are enrolled for four years. Students desiring commissions in the Marine Corps follow a different curriculum during the junior and senior years. Students may apply for flight or nuclear power training or for a commission in the Civil Engineer Corps, Supply Corps or Unrestricted Line during the senior year. A government financed flight indoctrination program consisting of ground and flight training is conducted by a civilian flying school during the junior or senior year for qualified students leading to a private pilot's license. The NROTC has three types of students: scholarship, college program and two-year college program, which is open to beginning juniors in good standing who contact the NROTC unit prior to April 1 of the sophomore year.

Scholarship Students

Scholarship students are appointed midshipman, USNR, after nationwide competition. They have their tuition, fees and textbooks paid for by the Navy for a period not exceeding four years, are uniformed at government expense and receive retainer pay at the rate of \$100 per month. Students in this classification will not be entitled to receive simultaneous education benefits under the G. I. Bill. They must obligate themselves to complete the prescribed naval science curriculum, to make a cruise of from six to eight weeks each summer, to accept a commission as ensign, USN, or second lieutenant, USMC, upon graduation, and to serve on active duty for four years after commissioning unless released earlier by the Navy Department. At the end of this period their active duty obligation to the Navy or Marine Corps is fulfilled. If they do not desire to remain on active duty in the regular Navy or Marine Corps, they are ordered to inactive duty in the Navy or Marine Corps Reserve.

College Program Students

College program students, enrolled under the provision of Public Law 88-647, are uniformed at government expense and, during their junior and senior years, receive retainer pay of \$100 per month. They must complete the prescribed naval science curriculum, make a summer cruise of approximately six weeks during the summer after the junior year, and upon graduation accept a commission as ensign, USNR or second lieutenant, USMCR.

In consideration for the benefits accrued by reason of membership in the NROTC college program, prior to starting the junior year the student is required to enlist in the U. S. Naval Reserve for a period of six years. He must agree to serve on active duty for not less than three years after appointment to commissioned rank in the U. S. Naval Reserve or Marine Corps Reserve and to retain his commission until the sixth anniversary of receipt of original commission. After receiving their commissions, college program students may apply for commission in the regular Navy or Marine Corps. Students may receive these benefits in addition to G. I. benefits to which they are entitled.

Naval Science Students

Any regularly enrolled undergraduate student may enroll as a naval science student. Those enrolled as naval science students take naval science courses as electives and have no contract with

the navy. They have no assurance of ultimate commissioning nor do they derive any of the financial benefits available to scholarship and college program students.

Selection Procedure

Scholarship students are selected in nationwide competitive examinations. The NROTC at Georgia Tech has no part in this selection although information about the scholarship program is available.

The professor of naval science may annually nominate several college program students to the chief of naval personnel for a scholarship. To apply for the college program, a student must be enrolled at Georgia Tech or attending an accredited college or university in the near vicinity and be at least 17 and not over 21 years of age. Applicants are selected to fill the quota based on physical qualifications, interview by naval officers, score on SAT and high school record. Applicants for the college program should apply at the Naval Armory during the designated days of freshman orientation week for the fall quarter.

Curriculum

All NROTC students follow the same curriculum during their freshman and sophomore years, attending two hours of naval science class and one hour of associated laboratory or drill each week.

Junior and senior line students attend three hours of naval science class and one or two hours of associated laboratory and drill each week.

Junior and senior Marine option students attend three hours of naval science class and two hours of associated laboratory and drill each week of the fall and winter quarters. Junior and senior Marine option students attend two hours of laboratory and drill each week of the spring quarter. In addition, during each of the junior and senior years, the Marine option requires a three or four-credit course selected from the following areas of study and approved by the professor of naval science: sociology, English, systems engineering, information science, psychology, philosophy and history of science, industrial engineering, industrial management, modern languages, history and political science.

In addition to the required naval science courses, all NROTC students must successfully complete the following institute courses: Pol. 3203, Pol. 3204, and P.E. 1010. All Navy option students must take calculus (Math. 1307-8 or Math 1713-4), Phys.

(2111, 2121 or 2141 series), and computer science (I.C.S. 1700, E.E. 1010, Math. 4625, M.S.C.I. 2000 or other approved course). All Marine option students must take two courses from the following areas of study as approved by the professor of naval science: sociology, English, systems engineering, information science, psychology, philosophy and history of science, industrial engineering, industrial management, modern language, history or political science.

Students who are enrolled in a six year architecture program must agree to accept a commission upon receipt of their Bachelor of Science degree.

No more than six hours of credit in basic naval science courses and no more than nine hours of credit in advanced naval science courses may be applied toward a degree.

Department of Physical Education and Recreation

(Established 1942)

Associate Professor and Head—Bill D. Beavers; *Associate Professors*—Byron A. Gilbreath, John C. Hyder, James H. McAuley, Tommy Plaxico; *Assistant Professors*—Carlos E. deCubas, James P. Culpepper Jr., Douglas L. Fowlkes, David W. Houser; *Instructor*—Russell W. Polhemus.

General Information

The Department of Physical Education and Recreation seeks to provide opportunities to develop new skills and gain information that will allow the student to lead a healthier and more productive life. The program of instruction includes both required and elective courses.

Required Physical Education

The object of the required courses is to give the student sound basic concepts regarding personal health, physical fitness and water safety. The majority of activity and skills courses are scheduled on two alternate days per week meeting two hours per day. One hour each day is devoted to class activity and one hour is allowed for dressing and shower.

All students entering Georgia Tech as freshmen are required to satisfactorily complete three credit hours of physical education. Female students must complete any three hours of physical

education to fulfill their physical education requirements. All physically qualified male students will be required to complete swimming (P.E. 1010) and any two of the remaining three offered in the required program (P.E. 1020, 1040 or 1050).

Students who are exempted for physical reasons from all or any of P.E. 1010, 1020, or 1050 will be required to satisfactorily complete P.E. 1040. The health information record will determine any exemption from physical education courses. All certificates of disability from personal physicians must be endorsed by Student Health Services before they will be accepted by the department.

Transfer students will be granted hour-for-hour work taken at other institutions. Students twenty-one years of age or older on first admission to the Georgia Institute of Technology will be exempt from required physical education.

Elective Physical Education

Following the completion of the physical education graduation requirement, the student may choose from a wide variety of elective courses to improve or maintain desired levels of physical fitness, or to learn new recreational and leisure time skills. All courses are offered on a coeducational basis.

School Of Physics

(Established in 1939)

Director—James R. Stevenson; *Associate Director and Regents' Professor*—Charles H. Braden; *Regents' Professors*—Harold A. Gersch, Earl W. McDaniel, L. David Wyly; *Professors*—R. Martin Ahrens, Earl E. Bortell (Emeritus), Harold R. Brewer, Vernon Crawford, Walter P. Ewalt (Emeritus), Martin R. Flannery, Joseph Ford, Ian R. Gatland, Don S. Harmer, Joseph H. Howey (Emeritus), David W. Martin, Eugene T. Patronis, Jr., Edward T. Prosser (Emeritus), Edwin J. Scheibner, Augustus L. Stanford, Edward W. Thomas, Jr., Henry S. Valk, Thomas L. Weatherly, Michael K. Wilkinson (Adjunct), J. Quitman Williams, R.A. Young; *Associate Professors*—Helmut Birtz, Harry G. Dulaney, Ronald F. Fox, James M. Tanner, Oscar B. Wike, LeRoy A. Woodward; *Assistant Professors*—David B. Dusenbery, Nisbet S. Kendrick, Donald A. McClure, Donald C. O'Shea, Roger M. Wartell, William E. Woolf.

General Information

Physics has been known primarily as a basic science, and fundamental research into the principles of physics continues to

occupy the attention of many physicists. But the study of physics has also become increasingly important as a basis for fundamental research in interdisciplinary areas such as biophysics and chemical physics and as an applied science in government and industry. Furthermore, as society becomes more technically oriented, an education in physics may provide an advantageous pre-professional foundation.

The School of Physics offers basic service courses to freshmen and sophomores, some advanced service courses for students of engineering, science or mathematics, and advanced work leading to the bachelor's, master's and the doctoral degree in physics. The school seeks to provide elective freedom in its undergraduate and graduate degree programs in order to enable students with a wide variety of interests to work out suitable programs of study.

In addition to offering courses in the fundamentals of physics the school provides numerous specialized courses at the undergraduate and graduate levels, especially in areas related to the research interests of the faculty. Current faculty research interests include acoustics, atomic collisions, cosmic rays, elementary particle theory, low-temperature physics, many-body theory, molecular physics, nuclear physics, solid-state physics, statistical mechanics, physics instruction and interdisciplinary areas in biophysics and materials science. Opportunities exist in these areas, as well as in some other areas by collaboration with faculty members of other departments, for undergraduate and graduate special problems, master's theses and doctoral dissertations.

Information supplementary to this catalog that may be useful to students in the planning of programs of study is available from the School of Physics. A graduate brochure which further describes the opportunities for graduate study and research is available upon request.

Undergraduate Programs

The School of Physics offers two undergraduate degrees, the Bachelor of Science in Physics and the Bachelor of Science in Applied Physics. The basis of the former degree program is the traditional preparation of a student for graduate study in physics. The degree program in applied physics may be better suited for entry into industry or government upon graduation, preparation for further professional training (medicine, law, dentistry or business) or preparation for graduate study in some other disciplines. The two degree programs differ in that a few courses intended primarily as preparation for graduate study in physics in the traditional program are replaced by courses oriented toward the applications of physics in the applied physics program.

Each of the baccalaureate programs comprises: (a) courses needed to meet general institutional degree requirements, (b) a core of technical courses intended to give a strong background in mathematics and in the physical principles of mechanics, electricity and magnetism, thermodynamics and the quantum theory which governs physical phenomena at the microscopic level of molecules, atoms and nuclei, (c) technical electives which enable the student to explore areas of his choice in greater depth and (d) free electives, about one quarter of the total hours, which may be employed to schedule additional technical or non-technical courses.

The considerable flexibility inherent in the physics curricula is advantageous to students who wish to work out individual programs of study. At the same time, this flexibility suggests the need for consultation with advisers in order that good use may be made of the elective hours and in order to avoid scheduling difficulties that might arise in later quarters.

Many students who earn a degree in physics have transferred from another discipline. The degree programs have been planned to enable most students to transfer into physics at any time prior to their junior year with little or no loss of credit.

A total of 196 credit hours is required for each bachelor's degree in physics. A grade point average of at least 2.0 in physics courses numbered 3000 and higher is a requisite for the degree.

Bachelor of Science in Physics Curriculum

Freshman Year

Course No.	Subject	1st Q.	2nd Q.	3rd Q.
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Chem. 1101-2 ¹	General Chemistry	4-3-5	4-3-5	.....
Phys. 2121 ²	General Physics	.....	.....	4-3-5
Engl. 1001-2-3 ³	Analysis of Literature	3-0-3	3-0-3	3-0-3
Electives ^{4, 5}	Social Science			
	or Humanities	3-0-3	3-0-3	3-0-3
Electives ⁶	Physical Education	0-4-1	0-4-1	0-4-1
Electives ^{7, 8, 9}		.....	3-0-3	3-0-3
	Totals	15-7-17	18-7-20	18-7-20

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Math. 2307-8	Calculus IV, V	5-0-5	5-0-5	.....
Math. 2309 ¹⁰	Differential Equations	.....	.....	5-0-5
Phys. 2122-3	General Physics	4-3-5	4-3-5	.....
Electives ^{4, 5}	Social Science	3-0-3	3-0-3	3-0-3
Electives ^{4, 5}	Humanities or Social Science	3-0-3	3-0-3	3-0-3
Electives ⁹				6
	Totals	15-3-16	15-3-16	11-0-17

Notes are listed following the program for the Bachelor of Science in Applied Physics.

Junior and Senior Years

<i>Course No.</i>	<i>Subject</i>	<i>Credit Hrs.</i>
Phys. 3121-2-3	Classical Mechanics and Electricity and Magnetism (5-0-5 each)	15
Phys. 3141	Thermal Physics	5
Phys. 3143	Quantum Mechanics I	5
Electives	Physics electives which must include at least three of the following: Phys. 3211, 3224, 3226, 3229, 3244, 3253, 4211, 4212, 4214, 4215, 4216, 4265, 4266, 4321, 4322, 4323 or other approved laboratory courses	20
Electives, to bring total hours to 196 (not more than nine hours in advanced ROTC)		45
	Total, junior and senior years	90

Bachelor of Science in Applied Physics Curriculum

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1101-2 ¹	General Chemistry	4-3-5	4-3-5	.....
Phys. 2121 ²	General Physics	.....	.....	4-3-5
Engl. 1001-2-3 ³	Analysis of Literature	3-0-3	3-0-3	3-0-3
Electives ⁴	Social Science or Humanities	3-0-3	3-0-3	3-0-3
Electives ⁶	Physical Education	0-4-1	0-4-1	0-4-1
Electives ^{7, 8}		.....	3-0-3	3-0-3
	Totals	15-7-17	18-7-20	18-7-20

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Math. 2307-8	Calculus IV, V	5-0-5	5-0-5	.....
Math. 2309 ¹⁰	Differential Equations	.....	.....	5-0-5
Chem. 2113 ¹¹	Chemical Principles	.....	.....	3-3-4
Phys. 2122-3	General Physics	4-3-5	4-3-5	.....
E.Gr. 1170	Introduction to Visual Communication	.....	2-3-3	.....
Electives ¹²	Computer Programming	.....	.....	3
Electives ⁴	Social Science	3-0-3	3-0-3	3-0-3
Electives ⁴	Humanities or Social Science	3-0-3	3-0-3	3-0-3
	Totals	15-3-16	17-6-19	14-3-18

Junior and Senior Years

<i>Course No.</i>	<i>Subject</i>	<i>Credit Hrs.</i>
Phys. 3132	Intermediate Mechanics	3
Phys. 3136	Intermediate Electricity and Magnetism	3
Phys. 3143	Quantum Mechanics I	5

Junior and Senior Years (continued)

Course No.	Subject	1st Q.	2nd Q.	3rd Q.
Phys. 3211	Electronics			7
Electives	Technical electives which must include at least six credit hours of laboratory work. These courses need not all be in physics but they must be approved by the School of Physics			25
Electives, to bring total hours to 196 (not more than nine hours in advanced ROTC)				43
	Total, junior and senior years			86

¹Students contemplating advanced work in chemistry should consider taking Chem. 1111-2 in lieu of Chem. 1101-2.

²Students who have demonstrated competence in mathematics should consider taking Phys. 2141-2-3 in lieu of Phys. 2121-2-3. Some students, e.g. biophysics students or pre-medical students, will find it advisable to commence upper level chemistry courses during their sophomore year. They should schedule Chem. 2113 in the third quarter of the freshman year and defer the start of the general physics sequence until the sophomore year.

³Students whose scores on the College Board SAT-Verbal and the English achievement examinations are sufficiently high may, in consultation with the Department of English, replace courses in the Engl. 1001-2-3 sequence by other English courses.

⁴See "Information for Undergraduate Students" section of this catalog for information relative to the 36 credit hour requirement in the humanities and the social sciences.

⁵It is recommended that students who contemplate doctoral work in physics include study of the French, German or Russian languages in their programs.

⁶See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁷If ROTC is elected, the first course should be scheduled during the first quarter the student is in attendance.

⁸Physics majors are advised to elect Phys. 1000, Physics Orientation, during the freshman year.

⁹A course in computer programming is recommended during the freshman or sophomore years, e.g. I.C.S. 1700, C.E. 2502, E.E. 1010, M.E. 3016 or Phys. 3263.

¹⁰Students who have demonstrated competence in mathematics should consider taking Math. 3308 in lieu of Math. 2309.

¹¹Phys. 3141 or M.E. 3720 may be substituted for Chem. 2113, however, students who expect to take additional chemistry courses should schedule Chem. 2113.

¹²This requirement may be met by scheduling one of the following courses: I.C.S. 1700, C.E. 2502 (plus one additional elective hour), E.E. 1010, M.E. 3016, Phys. 3263 or other computer course approved by the School of Physics.

Use of Elective Hours

Students may utilize their elective freedom in the physics curricula to specialize in particular areas of physics, to prepare for careers

in interdisciplinary areas of science, as a pre-professional program or to gain a background in other technical or non-technical disciplines. The School of Physics has formulated and has available suggestions for use of elective hours should the student wish to direct his education in one of the following directions: graduate study in physics, acoustics, applied optics, biophysics, geophysics, health physics, instrumentation, materials science, pre-business/management or pre-medical. In addition, elective hours may be used for special problems (Phys. 3900 or 4900) conducted under the supervision of a faculty member. A student need not follow any of the suggested elective programs, and elements of several programs may be combined to suit the needs and interests of the individual student.

Graduate Programs

Master's Program. The school offers two master's programs, a regular program leading to the Master of Science in Physics and an applied program leading to the Master of Science in Applied Physics degree.

The requirements for the degree Master of Science in Physics may be fulfilled on the basis of 50 hours of course work, or a master's thesis may be elected in lieu of 17 hours of courses. The course requirement is generally satisfied as a part of the doctoral program. Although there are no rigid course requirements for the regular master's degree, most students are advised to include the equivalent of Phys. 4143, at least three courses from Phys. 6121, 6122, 6123 and 6141, and mathematics equivalent to Math. 4582 and 4321 or Math. 4347 and 4348. If the master's degree is to be a terminal degree, a substantial research component should be included in the program either by election of a thesis or by including a number of hours of special problems (Phys. 8501-2-3 or 8511-2-3).

The program leading to the degree Master of Science in Applied Physics is designed for students who wish to terminate their study of physics with the master's degree as preparation for a career in industry, government, high school or junior college teaching, or as preparation for further study in another discipline. The program includes several courses of general significance in applied physics (Phys. 4143, 6131, 6132 and 6231 and mathematics equivalent to 4582 and 4321) plus the student's choice from a wide selection of specific programs in applied physics including acoustics, health physics, optics, physical characterization of materials and physics instruction. Students work out individual study programs in consultation with a guidance committee. Each program will include practical

laboratory experience working with staff members who have active research programs in applied physics. The inclusion of one or more courses in the general areas of business principles or engineering economics is encouraged.

Doctoral Program. The Doctor of Philosophy degree is directed toward the goal of attaining proficiency in the conduct of independent scholarly work. The degree program comprises course work in the principles of physics, additional specialized courses both in the area of the doctoral thesis and in one or two other areas, demonstration of reading competence in a foreign language, the passing of a comprehensive examination, and an independent research investigation.

There are no definite course requirements for the doctoral degree in physics. Most students find that they will schedule about 65 hours of courses and that completion of Phys. 8001-2-3, 6121-2-3, and 6141 is advisable prior to taking the comprehensive examination. Physics 6143 and mathematics equivalent to Math. 6511-2-3 are recommended for most doctoral candidates. A grade point average of 2.9 in courses taken while a graduate student is required to register for the comprehensive examination and is a requisite for the degree.

Students are encouraged to commence participation in the departmental research programs early in their graduate careers. The undertaking of a doctoral thesis is usually reserved until the comprehensive examination is passed, which may occur during the second graduate year for a well prepared student.

School Of Psychology

(Established in 1959)

Director and Professor—Edward H. Loveland; *Regents' Professor Emeritus*—Joseph E. Moore; *Professors*—Randall M. Chambers, Richard K. Davenport, M. Carr Payne, Jr., Sam C. Webb; *Associate Professors*—E. Jo Baker, M. Jackson Marr, Stanley A. Mulaik, Charles V. Riche, William W. Ronan, C. Michael York; *Assistant Professors*—G. Dale Baskett, Anderson D. Smith; *Lecturers*—Rodabe Bharucha-Reid, Edmund O. Martin.

General Information

The School of Psychology serves a dual function in the institute. First, it offers training in the basic and applied aspects of the science of behavior for the student majoring in architecture, engineering, industrial management and natural sciences. It also

offers programs of study leading to the Bachelor of Science in Applied Psychology, and the Master of Science and Doctor of Philosophy in Psychology.

The undergraduate curriculum in psychology stresses fundamentals, providing opportunity for broad training in mathematics, the natural sciences, humanities and management. The large number of elective courses enables the curriculum to fulfill a wide variety of educational and vocational needs. Graduates have been able to engage successfully in post-graduate study in many fields including business administration, history, industrial management, labor relations, law, medicine, music, psychology and theology.

The program provides excellent preparation for graduate work in psychology, and is especially adaptable to pre-medical education. Graduates of the program also have been employed successfully in a variety of positions relating to personnel subsystems (including human engineering), personnel research, personnel service, systems development, management and the administration of business, engineering and health programs.

Undergraduate Curricula

The general option, which is extremely flexible, permits students to prepare for post-graduate study in psychology and a number of other fields, or for employment immediately after graduation. Students in this option are, through appropriate choices of elective courses, able to create a minor area of study.

The linguistic option combines a major in psychology with a coherent minor in linguistics to prepare students for graduate study in linguistics or in areas of psychology relating to the study of language. It also prepares students for work with cultural groups in which linguistic problems exist as significant variables in education or in vocational preparation and placement. Specific details concerning this option are available in the School of Psychology office.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1101-2	General Chemistry	4-3-5	4-3-5	.....
I.C.S. 1700	Digital Computer Organization and Program- ming	.....	.....	2-3-3

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Engl. 1001-2-3	Introduction to Literature	3-0-3	3-0-3	3-0-3
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives ¹	Modern Language or Social Science	3-0-3	3-0-3	3-0-3
Electives ²	Physical Education	0-4-1	0-4-1	0-4-1
Electives ³	Free	2-0-2	2-0-2	2-0-2
	Totals	17-7-19	17-7-19	15-7-17

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Engl. 2001-2-3	Survey of the Humanities	3-0-3	3-0-3	3-0-3
Math. 2307	Calculus IV	5-0-5	.....	.....
Math. 2308	Calculus and Linear Algebra	.....	5-0-5	.....
Biol. 2210-1	Principles of Biology	4-3-5	4-3-5	.....
Psy. 3303-4	General Psychology	.....	3-0-3	3-0-3
Psy. 4401	Industrial Psychology	.....	.....	3-0-3
Electives	Free	3-0-3	.....	6-0-6
	Totals	15-3-16	15-3-16	15-0-15

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Math. 2205-6	Elementary Statistical Analysis	3-0-3	3-0-3	.....
Psy. 4403	Introduction to Psychological Testing	.....	3-0-3	.....

Junior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Psy. 4405	Seminar in Organizational Psychology	3-0-3	.....	.....
Psy. 4406	Psychological Statistics	.....	.....	2-3-3
Psy. 4407	Experimental Psychology I	.....	.....	2-3-3
Psy. 4410	Social Psychology	.....	.....	2-3-3
Phys. 2121	Particle Dynamics	4-3-5	.....	.....
Phys. 2122	Electromagnetism	.....	4-3-5	.....
Phys. 2123	Optics and Modern Physics	.....	.....	4-3-5
Electives ⁴	Free	6-0-6	6-0-6	3-0-3
	Totals	16-3-17	16-3-17	13-12-17

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Psy. 4411	Experimental Psychology II	3-3-4	.....	.....
Psy. 4412	Psychology of Learning	.....	3-3-4	.....
Psy. ⁵ 4413	Applied Experimental Psychology	.....	.....	3-3-4
Psy. 4414	Special Problems	.....	0-3-1	.....
Psy. 4415	Special Problems	.....	.....	3-3-4
Engl. 3015	Public Speaking	.....	3-0-3	.....
Electives ⁴	Free	15-0-15	9-0-9	9-0-9
	Totals	18-3-19	15-6-17	15-6-17

¹Choice of (1) two quarters of one of the following: American history, political science, philosophy and history of science, or sociology, with the third quarter selected from one of the three remaining areas or (2) three quarters of modern language in either German, French or Spanish. Three quarters of either M.L. or S.S. are required.

²See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

³These free elective courses may be taken at any time during a student's course of

study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled.

*A total of not more than nine hours of electives may be in advanced ROTC.

*Psychology 6602 may be substituted for Psychology 4413 with the approval of the School of Psychology and dean of the graduate school.

Graduate Curricula

Doctoral and master's candidates share a core curriculum of required courses which include three proseminars in general psychology, nine additional course hours in psychology to be prescribed by the student's faculty advisory committee with the approval of the director of the School of Psychology and 18 hours to be chosen by the student, with the approval of his advisory committee, from among courses in psychology and other fields. Permission to substitute another course for a required course may be granted if the student can demonstrate competence in course content by passing a written examination. Doctoral candidates are expected to complete all requirements for the master's degree including a thesis and a demonstrated reading proficiency in one foreign language.

The master's degree is viewed as a significant educational achievement in itself, and is not awarded routinely for completion of part of the doctoral program. Master's programs are intended to prepare the student for continuation of graduate work toward the Ph.D., for professional work in business, industrial, governmental or educational positions, or for both. The master's degree will require two years for most students. A master's thesis is required.

The doctoral program provides the student with an opportunity for advanced study in general experimental, industrial, organizational or engineering psychology. Each of these curricula consists of additional courses and programs of individual study and research beyond the core curriculum, which contribute to a strong background in general experimental psychology and the student's area of specialization. The doctoral program will ordinarily require four years for students who enter immediately after obtaining the bachelor's degree.

Admission to graduate study in psychology with full graduate standing in the School of Psychology requires the equivalent of an undergraduate major in psychology or a related field with courses in general and experimental psychology, psychological statistics, testing and measurement and either industrial psychology or social psychology. Supplementary education in such areas as biology, chemistry, physics, engineering, foreign languages and particularly mathematics is strongly advised. Students who have considerable undergraduate preparation in one or more of these

areas may, with the approval of the School of Psychology, forego some of the required psychology courses. All applicants should submit scores on the Miller Analogies Test and the Graduate Record Examination.

The psychology faculty encourages competent students in subjects other than psychology to apply for admission.

Department of Social Sciences

(Established in 1948)

Department Head—Patrick Kelly; *Department Head Emeritus*—George Hendricks; *Professors*—Edward A. Gaston, Jr., John C. Gould, Melvin Kranzberg (Callaway Professor of History of Science and Technology), Morris Mitzner, Robert Scharf (Emeritus), Glenn N. Sisk (Emeritus), Willard E. Wight; *Associate Professors*—James E. Brittain, Germaine M. Reed, Sandra W. Thornton; *Assistant Professors*—Ronald H. Bayor, Barry L. Bozeman, John N. Hines, John J. Johnston, William E. McAlpine, Michael W. McKinney, Robert C. McMath, Jr., Daniel S. Papp, Thomas D. Philips, Frederick A. Rossini, Robert K. Whelan, Dorothy C. Yancy; *Instructors*—Barbara C. Karcher, Thomas S. Pearce.

General Information

The Department of Social Sciences offers coursework in four disciplines: history, philosophy and history of science, political science and sociology. Each of the disciplines has a dual function in the Georgia Tech academic community. On the one hand they perform their vital traditional roles of helping the student cultivate a critical awareness and perspective on the perennial evaluative issues that confront man, both as an individual and as a member of a complex social order. On the other, they reflect upon and contribute to the resolution of the scientific and technological issues that are Georgia Tech's special province.

The Department of Social Sciences has developed eight unofficial minors options to assist the student in identifying flexible, yet coherent programs of study in areas other than his major: American political systems, history of science and technology, international affairs, philosophy of science, American studies, science, technology, and society, urban affairs, and sociopolitical systems (open to psychology majors only). Though not as extensive as a major, a minor will enable the student to acquire additional conceptual skills and perspectives. Development of

minors is elective with no formal requirement as to number of hours; however, a minimum of 15 to 18 hours is recommended.

United States And Georgia History And Constitution Requirements

The State of Georgia requires all students to display a knowledge of U.S. and Georgia constitutions and U.S. and Georgia history.

To complete the requirement in U.S. and Georgia constitutions, a student must pass Pol. 1251 or 3200, or an examination on the U.S. and Georgia constitutions.

To complete the requirements in U.S. and Georgia history, a student must either pass Hist. 1001, 1002, 3010 or 3011, or pass an examination on U.S. and Georgia history.

Examinations for both requirements are administered each quarter to first quarter seniors by the Department of Social Sciences. Students who do not take the exams or who are unsuccessful must then take the appropriate course(s) prior to graduation.

College Of Industrial Management

Dean – Ferdinand K. Levy; *Associate Deans* – Gloria M. Shatto, Richard D. Teach; *Regents' Professors* – John L. Fulmer, Glenn W. Gilman; *Callaway Professor* – J. Leslie Livingstone; *Professors Emeritus* – Maurice R. Brewster, Hubert E. Dennison, William J. Proctor; *Professors* – Aristides F. Abril, Philip Alder, W. Carl Biven, E. R. Bollinger, James L. Caldwell, Robert W. Carney, Kong Chu, Sherman F. Dallas, Ramon G. Gamoneda, R. Earl Green, Mack A. Moore, Roderick A. O'Connor, William F. Schaffer, Fred A. Tarpley; *Associate Professors* – Fred C. Allvine, Peter H. Aranson, K. R. Balachandran, Andrew J. Cooper, John T. Etheridge, John R. Kaatz, Jack Kleiner, George E. Maddox, David B. Meltz, Tracy W. Murray, Lester A. Neidell, Ashford Stalnaker, Fred E. Williams; *Assistant Professors* – Karl Asmus, David Cheng, James F. Courtney, Gerald J. Day, Modesto Garcia, David M. Herold, David L. Kelly, Marlin V. Law, Gary M. Leff, Michael Long, Gary M. Mullet, Paul G. Munyon, David C. Nachman, Peter G. Sassone, John M. Stepp, Samuel R. Stivers; *Instructors* – Dallas F. Gay, Richard K. Robinson.

General Information

The College of Industrial Management prepares students for careers as managers or for additional study at the graduate level, stressing long-range career objectives rather than specific job knowledge. The continuing growth in number of organization and the increasing complexity of modern industrial and governmental operations have resulted in a great need for college graduates with formal preparation in management and economics.

The College of Industrial Management offers three undergraduate programs leading to the Bachelor of Science in Industrial Management, the Bachelor of Science in Management Science and the Bachelor of Science in Economics and offers graduate programs leading to the Master of Science in Industrial Management, the undesignated Master of Science and the Doctor of Philosophy.

All three undergraduate degree programs contain an essentially common core. Each program allows sufficient flexibility for the student to follow his own educational goals. Complex problem-solving takes place in a technical, social and political environment; therefore, the tools of management and economics are enhanced by an understanding of the natural and life sciences, humanities, the social sciences and the environment of the business enterprise. Every student is thus required to take substantial work in these subjects in addition to courses such as accounting, economics, computer applications, marketing, production and finance.

Only students who demonstrate their ability to successfully complete the requirements of the program are permitted to transfer into the College of Industrial Management from other majors at Tech. Therefore, it is definitely to the student's advantage to determine as early as possible in consultation with the associate dean of the College of Industrial Management the requirements that must be met before transfer will be permitted.

Bachelor of Science in Industrial Management

The industrial management degree program develops students with a broad interest in all management activities and operating problems. The program builds upon knowledge of the functional, environmental, behavioral, economic and legal aspects of business, and provides analytical and conceptual tools for analyzing complicated problems. It prepares the student for managerial responsibilities and decision making. The large number of elec-

tive hours allows the student, with his adviser, to tailor a program to his individual educational objectives. Elective concentration may be developed in such areas as organizational behavior, finance, accounting, computer applications, marketing, industrial relations and general management.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ¹	Science	X-X-4	X-X-4	X-X-4
Engl. 1001-2-3	Introduction to Literature	3-0-3	3-0-3	3-0-3
Electives	Social Science or Modern Language	3-0-3	3-0-3	3-0-3
Electives ²	Mathematics	5-0-5	5-0-5	5-0-5
Electives ³	Physical Education	0-4-1	0-4-1	0-4-1
	Totals	16	16	16

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ⁴	Engineering/Science/ Mathematics	X-X-3	X-X-3	X-X-3
Engl. ⁵ 2001-2-3	Survey of the Humanities	3-0-3	3-0-3	3-0-3
Econ. 2000-1	Principles of Economics I, II	.....	3-0-3	3-0-3
Mgt. 2000-1-2	Accounting I, II, III	3-0-3	3-0-3	3-0-3
M.Sci. 2000	Management Applications of Data Processing	2-3-3	.....	.....
Electives	Modern Languages/ Social Science/ Psychology	3-0-3	.....	.....
Electives	Non-Industrial Management	.....	3-0-3	3-0-3
	Totals	15	15	15

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ⁶	Intermediate Economics	3-0-3	3-0-3	.....
Elective	Either Mgt. 3100, Statistics I or Mgt. 3111, Statistics II	3-0-3	.....	.....
M.Sci. 3400	Analytical Methods in Management I	.....	3-0-3	.....
Mgt. 3260	Law I	.....	.....	3-0-3
Mgt. 3060	Finance I	3-0-3	.....	.....
Mgt. 3300	Marketing I	3-0-3	.....	.....
Elective ⁷	Marketing	.....	3-0-3	.....
Engl. 3015	Public Speaking	.....	.....	3-0-3
Mgt. 3150	Management Theory	3-0-3	.....	.....
Electives	Industrial Management	.....	3-0-3	3-0-3
Mgt. 4350	Production Management I	.....	.....	3-0-3
Elective	Either Mgt. 3061, Finance II or Mgt. 3070, Science Model in Finance	.....	3-0-3	.....
Mgt. 4200	Industrial Relations	.....	.....	3-0-3
	Totals	15-0-15	15-0-15	15-0-15

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Elective ⁸	Organizational Behavior	3-0-3	.....	.....
Electives	Industrial Management	6-0-6	6-0-6	3-0-3
Elective	Non-Industrial Management	3-0-3	.....	.....
Electives	Free	3-0-3	6-0-6	9-0-9

Senior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Elective	Psychology/Social Science/Modern Language	.....	3-0-3	.....
Mgt. 4195	Integrated Manage- ment Problems	.....	.....	3-0-3
	Totals	15-0-15	15-0-15	15-0-15

¹Science — one year of science is required in chemistry, biology or physics (complete series).

²The math requirements may be satisfied with one of the following sequences as determined by the student's high school background: Math. 1710, 1711, 1712, Math. 1711, 1712, 1713 or Math. 1307, 1308, 1711.

³No student may receive credit for more than three hours of P.E. towards degree. See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁴One year required of approved engineering courses, science or advanced math not required by the core curriculum. Engineering orientation courses may not be used to fulfill the requirement.

⁵English 2004 or 2007 may be substituted for English 2003.

⁶Choice of two of the intermediate economics courses 3000, 3001, 3002.

⁷Mgt. 3301, 3310, 3320, 3330, 4331 or 4335.

⁸Mgt. 3100, 4100 or 4110.

Bachelor of Science in Economics

Among the complex problems facing society today, economic issues stand in the forefront. Social objectives such as full employment, price stability, economic growth, adaptation to technological advances, efficiency in the management of complex industrial organizations and international prosperity all receive high priority in the nation's agenda. The program in economics, based on the management core, enables students to analyze complex economic problems and to understand policies for their solution.

Modern economics is analytically rigorous. The curriculum for this option prepares the student to cope with the advances that have been made in this field of study. The program requires a background in mathematics, statistics and economic theory.

The economics degree is suitable for students who wish to major in an academic discipline, as opposed to a professional discipline, at the undergraduate level. Students also obtain professional management training through the elective courses in

management. The degree in economics provides an excellent background for graduate work in economics, other social sciences or management.

Freshman Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ¹	Science	X-X-4	X-X-4	X-X-4
Engl. 1001-2-3	Introduction to Literature	3-0-3	3-0-3	3-0-3
Electives	Modern Language/ Social Science/ Psychology	3-0-3	3-0-3	3-0-3
Electives ²	Mathematics	5-0-5	5-0-5	5-0-5
Electives ³	Physical Education	0-4-1	0-4-1	0-4-1
	Totals	16	16	16

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Electives ⁴	Engineering/Science/ Mathematics	X-X-3	X-X-3	X-X-3
Engl. ⁵ 2001-2-3	Survey of the Humanities	3-0-3	3-0-3	3-0-3
Mgt. 2000-1	Accounting I, II	3-0-3	3-0-3	.....
Econ. 2000-1	Principles of Economics I, II	3-0-3	3-0-3	.....
Econ. 3000	Economic Theory of the Firm	.....	.....	3-0-3
M.Sci. 2000	Management Applications of Data Processing	3-0-3	.....	.....
Elective	Modern Language or Social Science	.....	3-0-3	.....
Elective	Free	.....	.....	6-0-6
	Totals	15	15	15

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Econ. 3001	National Income Analysis	3-0-3	.....	.....
Econ. 3002	Money and Banking	.....	3-0-3	.....
M.Sci. 3110-1	Statistics I, II	3-0-3	3-0-3	.....
M.Sci. 3400	Analytical Methods in Management I	.....	3-0-3	.....
Mgt. 3150	Management Theory	3-0-3	.....	.....
Mgt. 3060-1	Finance I, II	3-0-3	3-0-3	.....
Mgt. 3300 ⁶	Marketing I	3-0-3	.....	.....
Elective ⁶	Marketing	.....	3-0-3	.....
Mgt. 4350	Production Management I	.....	.....	3-0-3
Engl. 3015	Public Speaking	.....	.....	3-0-3
Econ. 3100	Econometrics I	.....	.....	3-0-3
Econ. 4000	Topics in Advanced Microeconomics	.....	.....	3-0-3
Mgt. 4200	Industrial Relations	.....	.....	3-0-3
	Totals	15-0-15	15-0-15	15-0-15

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Elective ⁷	Organizational Behavior	3-0-3	.....	.....
Elective	Modern Language/ Social Science/ Psychology	3-0-3	.....	.....
Elective	Economics	9-0-9	3-0-3	3-0-3
Electives	Free	.....	6-0-6	9-0-9
Econ. 4050	Monetary Theory and Policy	.....	3-0-3	.....
Econ. 4400	History of Economic Thought	.....	3-0-3	.....
Econ. 3095	Economic Policy	.....	.....	3-0-3
	Totals	15	15	15

¹One year of science is required in chemistry, biology or physics. Must complete series in same area.

²This mathematics requirement may be satisfied by one of the following sequences as determined by the student's background from high school: Math. 1711, 1712, 1713; Math. 1307, 1308, 1711 or Math. 1307, 1308, 1309, 2307, 2308.

³No student may receive credit for more than three hours of P.E. towards degree. See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁴One year required of approved (non-survey) engineering courses, science or advanced math not required by the core curriculum. Engineering orientation courses may not be used to fulfill the requirement.

⁵Engl. 2004 or 2007 may be substituted for Engl. 2003.

⁶May substitute any course taught by the I.M. college.

⁷Mgt. 3100, 4110 or 4100.

Bachelor of Science In Management Science

The management science program is designed for the student who possesses strength and interest in applying mathematics to managerial problems. The program, based upon a foundation of applied mathematics and the institutional aspects of the modern business, develops analytical modes organized to allocate resources within the firm. The curriculum also contains a three-course sequence of specialization which permits the student either to concentrate in an applied area or to strengthen his theoretical foundation.

Graduates of the option will typically be employed as staff analysts in industry and government, as systems analysts or in a wide variety of positions where a high degree of analytical ability is required. The program also provides a strong base for graduate study in business, economics, management science, operations research and related areas.

Freshman Year

Course No.	Subject	1st Q.	2nd Q.	3rd Q.
Elective ¹	Science	X-X-4	X-X-4	X-X-4
Engl. 1001-2-3	Introduction to Literature	3-0-3	3-0-3	3-0-3
Math. 1307-8-9	Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives	Modern Language/ Social Science/ Psychology	3-0-3	3-0-3	3-0-3

Freshman Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Elective ²	Physical Education	0-4-1	0-4-1	0-4-1
	Totals	16	16	16

Sophomore Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Engl. ³ 2001-2-3	Survey of the Humanities	3-0-3	3-0-3	3-0-3
Math. 2307-8	Calculus IV, V	5-0-5	5-0-5	.....
Econ. 2000-1	Principles of Economics I, II	3-0-3	3-0-3	.....
Econ. 3000	Economic Theory of the Firm	.....	.....	3-0-3
M.Sci. 2000	Management Application of Data Processing	3-0-3	.....	.....
Mgt. 2000-1	Accounting I, II	3-0-3	3-0-3	.....
Mgt. 3150	Management Theory	.....	.....	3-0-3
Elective	Management	.....	.....	7-0-7
	Totals	17-0-17	14-0-14	16-0-16

Junior Year

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
M.Sci. 3200-1	Management Science I, II	3-0-3	3-0-3	.....
Math. 3215	Problems in Probability and Statistics	5-0-5	.....	.....
Elective	Probability and Statistics	.....	5-0-5	.....
Mgt. 4200	Industrial Relations	3-0-3	.....	.....
Elective	Either Mgt. 3100, 4100 or 4110 Organization Behavior	3-0-3	.....	.....
Mgt. 3060	Finance I	.....	3-0-3	.....
Mgt. 3300	Marketing I	.....	3-0-3	.....
Econ. 3100	Econometrics	.....	.....	3-0-3

Junior Year (continued)

<i>Course No.</i>	<i>Subject</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Elective	Marketing	.....	.....	3-0-3
Mgt. 3070	Management Science			
	Models in Finance	.....	.....	3-0-3
Engl. 3015	Public Speaking	.....	.....	3-0-3
Mgt. 4350	Production Management I	.....	.....	3-0-3
	Totals	14	14	15

Senior Year

<i>Course No.</i>	<i>Subject</i>	<i>Credit Hours</i>
Electives ⁴	Management Science Concentration	9
Electives ⁵	Advanced Mathematics	6
Electives ⁶	Specialization or Project	9
Electives	Free	18
Mgt. 4195	Integrated Management Problems	3
	Total Senior Year	45

¹One year of science is required in chemistry, biology or physics.

²No student may receive credit for more than three hours of P.E. toward degree. See chapter four, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

³English 2004 or 2007 may be substituted for English 2003.

⁴M.Sci. concentration electives, subject to M.Sci. adviser's approval are nine hours selected from Math. 3643, 4580, 4221, 4222, 4280, 4281, 4282, 4283, 4591, 4643, 4644, 4645, I.Sy.E. 4007, 4010, 4011, 4028, 4044, 4053, 4056 and M.Sci. 3300, 3401, 3402, 4110, 4120, 6101, 6105, 6106, 6102, 6410.

⁵Advanced math electives, subject to M.Sci. adviser's approval, six hours selected from Math. 2020, 3110, 4110, 4120, 4583, 4431, 4038, 4140, 4311-3, 4391, 4392, 4441, 4643, 4644, 4645.

⁶Specialization electives, subject to M.Sci. adviser's approval, nine hours in a specific subject area to be chosen from I.C.S. 2700, 3113, 3400, 3422, 3600, 3601, 4300, 4305, 4334, 4380, 4410, 4430, 4560, Psy. 4401, 4402, 4403, 4404, 4405, 4407, 4410, 4411, 4424, 4750 or from the courses listed under M.Sci. concentration electives or nine hours of special project M.Sci. 4991, 4992 and 4993.

Graduate Program

The College of Industrial Management offers graduate programs leading to the degrees of Master of Science in Industrial Manage-

ment (MSIM), the undesignated Master of Science and the Doctor of Philosophy.

The Master of Science in Industrial Management program, accredited by the American Association of Collegiate Schools of Business, is designed to give a professional management education to students with engineering, mathematics and science baccalaureate degrees. The program requires 72 hours of graduate course work or its equivalent. Industrial management courses or approved graduate courses in other schools of the institute may be taken as electives. A student may enter the master's program in any quarter without experiencing any scheduling difficulties, thus allowing the completion of the program in six consecutive quarters.

In addition to the regular programs, the College of Industrial Management offers an accelerated program that can be completed in four quarters. This program is designed to take only well qualified students and provide them with intensive and rigorous training for professional managers then place them in excellent positions upon completion. The program will take the student's full time with no time available for outside work.

The college also offers, in cooperation with the School of Nuclear Engineering, a Master of Science degree with an emphasis in nuclear power management.

A student may also pursue a program of study at the master's level in which a curriculum is designed to meet his individual needs. The course requirements are specified during a conference between the student and his adviser.

The doctoral program in the College of Industrial Management has three major areas of focus: economics, behavioral science and management science. Each of these areas is designed to complement and reflect the technological emphasis of the institute.

Doctoral students in industrial management are required to take a minor in economics. Students in economics are required to take a minor either from the non-economics offerings of the College of Industrial Management or from the offerings of other schools at Georgia Tech.

Comprehensive examinations, which include both a general and a special examination, are required of all doctoral students. The general examination will be given when the student completes one full year of graduate work, the special examination when the student completes his course work. The student will be admitted to candidacy after successful completion of the special examination and the approval of the prospectus of his dissertation. On completion of the dissertation the student will be required to take a final oral examination as prescribed in the general regulations of the graduate division.

5/ Courses of Instruction



TECH

How to Use This Chapter

Course descriptions are listed alphabetically by schools and departments of instruction. The specific degree requirements for each curriculum at both the undergraduate and graduate levels are listed alphabetically by colleges in chapter four of this catalog.

Course numbers below 3000 are lower division (freshman and sophomore) courses. Those numbered 3000 - 4999 are designated as upper division (junior and senior) courses. They are open to students of the lower and upper divisions with the proper prerequisites and to graduate students on approval of the individual student's major school. Courses designed for graduate students are numbered 5000 and above; the methods of presentation and quality of work expected make them generally unsuited to undergraduate participation. An upper-division undergraduate student is therefore permitted to enroll in a graduate-level course only after consultation with and approval of his major school and the dean of the graduate division.

Figures entered below the course number and title of each course signify the number of class hours per week, the number of laboratory hours per week and the quarter hours credit for the completed course, in that order. Thus, the entry 4-3-5 in Chemistry 1101 means that the course meets for four lecture hours per week, has three hours of laboratory work per week and is evaluated at five quarter hours credit upon completion of the quarter's work.

Aerospace Engineering

A.E. 1350. Introduction to Engineering

2-3-3.

Emphasizes creative imagination in engineering, rather than mathematics. The growth and behavior of biological systems are related to engineering problems.

A.E. 1750. Introduction to Bioengineering

3-0-3.

Introduction to aspects of science and technology pertinent to bioengineering. Also taught as E.E. 1750, E.S.M. 1750 and M.E. 1750.

A.E. 2100. Structures I

4-3-5. Prerequisite: E.S.M. 2201. Prerequisite or corequisite: Math. 2308.

Introduction to the elements of structural mechanics basic in the design of aircraft and missile structures.

A.E. 2600. Computer Applications in Aerospace Engineering I

1-0-1. Prerequisite: Math. 1308.

Description of the components of a modern digital computing system. Elementary FORTRAN programming. Introduction to aerospace engineering applications.

Text: at the level of *Fortran IV*

Programming for Engineers and Scientists, Murrill and Smith.

A.E. 2601. Computer Applications in Aerospace Engineering II

0-3-1. Prerequisite: A.E. 2600.

FORTRAN programming with emphasis on problem solving and program efficiency.

Text: at the level of *Fortran IV Programming for Engineers and Scientists*, Murrill and Smith.

A.E. 2602. Computer Applications in Aerospace Engineering III

0-3-1. Prerequisite: A.E. 2601.

Advanced programming, including creation and manipulation of program and data files. Solution of problems related to aerospace engineering.

Text: at the level of *Fortran IV Programming for Engineers and Scientists*, Murrill and Smith and *GT U1108 Users Manual*.

A.E. 3000. Fluid Mechanics I

4-3-5. Prerequisite: M.E. 3322, 2.0 overall average and a 2.0 average in math and in physics. Prerequisite or corequisite: Math. 2309.

The atmosphere, fluid properties, classification of flows and one-dimensional flows including isentropic flows, normal shocks and duct flows with friction and heating.

Text: Shapiro, *Compressible Fluid Flow, volume one*.

A.E. 3001. Fluid Mechanics II

4-3-5. Prerequisite: A.E. 3000.

The physical equations for continuum flows and applications to laminar and turbulent boundary layers for incompressible and compressible flow.

Text: at the level of Kuethe and Schetzer, *Foundations of Aerodynamics*.

A.E. 3002. Fluid Mechanics III

4-3-5. Prerequisite: A.E. 3001.

Two-dimensional incompressible flow theory, superpositioning and conformal transformations, with applications to flow around bodies and to airfoil theory.

Text: at the level of Kuethe and Schetzer, *Foundations of Aerodynamics*.

A.E. 3100. Structures II

4-3-5. Prerequisite: A.E. 2100

Prerequisite or corequisite: Math. 2309.

Analysis of three-dimensional trusses, thin-walled beams, and unsymmetrical bending. Introduction to theory of elasticity and application to two-dimensional problems.

Text: at the level of Rivello, *Theory and Analysis of Flight Structures*.

A.E. 3101. Structures III

4-3-5. Prerequisite: A.E. 3100.

Principle of virtual work and energy principles. Applications in linear and nonlinear elasticity. Introduction to stability analysis with application to simple models and to columns.

Text: at the level of Rivello, *Theory and Analysis of Flight Structures*.

A.E. 3102. Structures IV

4-3-5. Prerequisite: A.E. 3101.

Concept of redundancy; statically indeterminate structures. Torsion and bending of multi-cell box beams. Tension field beam. Shear lag concept. Application of matrix methods.

A.E. 4000. Fluid Mechanics IV

4-3-5. Prerequisite: A.E. 3002.

Finite wing theory, two-dimensional subsonic and supersonic compressible flows, super-

sonic flow around bodies of revolution and an introduction to transonics and hypersonics.

Text: At the level of Kuethe and Schetzer, *Foundations of Aerodynamics*.

A.E. 4100. Advanced Structures

3-0-3. Prerequisite: A.E. 3102 or consent of department.

Beam columns, shear webs with cut-outs, shear lag, bending in the plastic range, curved beams, miscellaneous thin metal structural problems.

A.E. 4120. Thermal Stresses

3-0-3. Prerequisite: A.E. 3102 or consent of department.

Origin of thermal stress, constraints, determination of temperatures, equations of uncoupled isotropic thermoelasticity, solutions of typical problems, properties of material at high temperatures, creep consideration.

A.E. 4200. Vibration and Flutter

3-0-3. Prerequisite: A.E. 3002, E.S.M. 4210. Prerequisite or corequisite: Math 4582.

Structural dynamics of one-dimensional systems. Analyses of static aeroelastic phenomena and flutter. Equations of motion for complete aeroelastic system and solution techniques.

A.E. 4250. Jet Propulsion

5-0-5. Prerequisite: A.E. 4000.

The theory and principles of jet propulsion. The mechanics and thermodynamics of combustion. Component and cycle analysis. Engine performance characteristics.

Text: at the level of Hill and Peterson, *Mechanics and Thermodynamics of Propulsion*.

A.E. 4350-1. Aerospace Engineering Design Project I, II

2-6-4 each. Prerequisite: A.E. 4000. Prerequisite or corequisite: A.E. 4500.

Preliminary design or case study of an aerospace system such as a complete flight vehicle, a propulsion system, a structural system or a control system.

Text: at the level of Perkins and Hage, *Airplane Performance, Stability and Control*.

A.E. 4400. Introduction to Propeller and Rotor Theory

3-0-3. Prerequisite or corequisite: A.E. 4000, or consent of department.

A study of the theory and equations used in the design of propellers and helicopter rotors.

Text: at the level of Gessow and Myers, *Aerodynamics of the Helicopter*.

A.E. 4500. Stability and Control

5-0-5. Prerequisite: A.E. 4000, E.S.M. 4210.

Principles of static lateral and longitudinal stability and studies of the equations and methods used in analysis. Applications to airplane and missile systems.

A.E. 4550. Instrumentation for Experimental Research I

2-3-3. Prerequisite: consent of department.

Laboratory treatment of major and ancillary instrumentation used in solid and fluid mechanics research, voltage, current, resistance measurement, transducers, amplifiers, oscilloscopes, recording equipment.

A.E. 4551. Instrumentation for Experimental Research II

2-3-3. Prerequisite: A.E. 4550 or consent of department.

Advanced treatment of laboratory instrumentation for research, analysis and application or operational amplifiers, filters and signal conditioners, elementary digital circuits, computer systems for data acquisition.

A.E. 4760. Engineering Acoustics and Noise Control I

3-0-3. Prerequisite: senior standing.

Study of acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, instrumentation, sound field in large and small rooms, noise legislation. Also taught as E.S.M. 4760, M.E. 4760.

A.E. 4761. Engineering Acoustics and Noise Control II

3-0-3. Prerequisite: A.E. 4760 or equivalent.

Continuation of A.E. 4760 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, enclosures, barriers, properties of materials, panel damping. Also taught as E.S.M. 4761, M.E. 4761.

A.E. 4803-13-23-33-43-53. Special Topics

3-0-3 each. Prerequisite: consent of department.

Course material devoted to special topics of current interest, treatment of new developments in various areas of aerospace engineering.

A.E. 4804-14-24-34-44-54. Special Topics

4-0-4 each. Prerequisite: consent of department.

Course material devoted to special topics of current interest,

treatment of new developments in various areas of aerospace engineering.

A.E. 4805-15-25-35-45-55. Special Topics

5-0-5 each. Prerequisite: consent of department.

Course material devoted to special topics of current interest, treatment of new developments in various areas of aerospace engineering.

A.E. 4900-1-2. Special Problems in Aerospace Engineering

Credit to be arranged. Prerequisite: third quarter junior or senior standing and approval of director.

Research on a problem selected in consultation with a faculty member. A brief description, endorsed by the adviser, must be approved by the school director.

A.E. 6000. Foundations of Fluid Mechanics

3-0-3. Prerequisite: consent of department.

Development of the conservation equations of a multicomponent, reacting fluid from both the continuum and molecular viewpoints. Stress tensor, heat transfer vector and diffusion velocity.

Text: at the level of Aris, *Vectors, Tensors and Basic Equations of Fluid Mechanics*.

A.E. 6010. Viscous Flow I

3-0-3. Prerequisite: consent of department.

Exact solutions of Navier-Stokes equations, Stokes flow, boundary layer equations, similarity solutions and integral methods for incompressible flow, compressible laminar boundary layer, viscous hypersonic flow.

A.E. 6011. Viscous Flow II

3-0-3. Prerequisite: A.E. 6010 or consent of department.

Transition from laminar to turbulent flow, equations of motion for turbulent flows, incompressible boundary layers, compressibility and heat transfer, semi-empirical methods, wakes and jets.

A.E. 6020. Elements of Compressible Flow

3-0-3. Prerequisite: consent of department.

Defining equations for inviscid compressible flows, method of characteristics for unsteady one-dimensional and steady two-dimensional and axially symmetric flows, nozzle design, conical flow.

A.E. 6021. Advanced Compressible Flow Theory I

3-0-3. Prerequisite: A.E. 6020 or consent of department.

The linearized potential equation, thin airfoil theory, similarity rules, linear theory for axially symmetric and three-dimensional flows.

A.E. 6022. Advanced Compressible Flow Theory II

3-0-3. Prerequisite: A.E. 6021.

Mixed subsonic – supersonic flows, transonic similarity rule, two-dimensional and axially symmetric bodies in transonic flow, selected topics.

A.E. 6023. Hypersonic Flow Theory

3-0-3. Prerequisite: A.E. 6021 or consent of department.

Hypersonic similarity rule, hypersonic small disturbance theory, Newtonian flow theory and other approximate methods, boundary layer interaction, the blunt body problem.

A.E. 6030. Advanced Potential Flow I

3-0-3. Prerequisite: A.E. 3002.

Development of the nonlinear and linearized unsteady potential flow equations. Solutions to incompressible flow problems of airfoils and wings undergoing steady, oscillatory and arbitrary motions.

A.E. 6031. Advanced Potential Flow II

3-0-3. Prerequisite: A.E. 6030.

Formulation of aerodynamic influence coefficients, solutions to subsonic, supersonic and hypersonic flow problems of wings and bodies experiencing oscillatory and arbitrary motions.

A.E. 6040. Rarefied Gasdynamics I

3-0-3. Prerequisite: consent of department.

Mass, momentum and energy transfer in linearized rarefied gas flows, free molecular external and internal flows, statistical models for collision integral of Boltzmann equation.

A.E. 6041. Rarefied Gasdynamics II

3-0-3. Prerequisite: A.E. 6040.

Mass, momentum and energy transfer in nonlinear rarefied gas and plasma flows, statistical models for diatomic and ionized gases, discussions of allied topics in ionospheric aerodynamics.

A.E. 6050. High-Temperature Gas Dynamics I

3-0-3. Prerequisite: A.E. 6260 or consent of department.

Real gas effects. Equilibrium properties and rate processes of high temperature gases. Equilibrium and frozen flows, normal and oblique shocks, nozzle flows, Prandtl-Meyer flows.

A.E. 6051. High-Temperature Gas Dynamics II

3-0-3. Prerequisite: A.E. 6050.

Acoustic equations and rate equations. Vibrational and chemical non-equilibrium flows, normal and oblique shock structures, theory of non-equilibrium characteristics, non-equilibrium acoustic waves, flow over corners.

A.E. 6100. Advanced Structural Analysis I

3-0-3. Prerequisite: A.E. 3101 or consent of department.

Stability of mechanical models, elastic bars and frames by kinetic and energy approaches, approximate methods for critical loads, dynamic stability and inelastic effects.

A.E. 6101. Advanced Structural Analysis II

3-0-3. Prerequisite: A.E. 6100 or consent of department.

Buckling of plates, torsional instability of thin open section columns, lateral buckling of beams, beams on elastic foundation, further discussion of dynamic stability.

A.E. 6102. Advanced Structural Analysis III

3-0-3. Prerequisite: A.E. 6100, E.S.M. 6372 or consent of department.

Stability of plates, cylindrical shells, edge effects, complete spheres and shallow spherical caps, recent developments.

A.E. 6103. Advanced Structural Analysis IV

3-0-3. Prerequisite: A.E. 3102 or consent of department.

Principle of virtual work. Concepts of potential energy and complementary energy, weighted residuals, applications in approximate solutions. Discussion of

Hookean materials, including thermal strains.

A.E. 6104. Advanced Structural Analysis V

3-0-3. Prerequisite: A.E. 6103 or consent of department.

Introduction to finite element analysis, with emphasis on the displacement analysis of structures. Applications to static equilibrium, vibration and stability. Nonlinear formulation, solution techniques.

A.E. 6105. Aerospace Structures Laboratory

1-6-3. Prerequisite: A.E. 6104 or consent of department.

Development of practical methods for experimental mechanics, design and execution of experiments, measurement of displacement, strain, force, acceleration, temperature, design of transducers and instrument systems.

A.E. 6120. Thermal Effects in Structures I

3-0-3. Prerequisite: Math. 4582.

Analysis of heat transfer in structural elements, development and use of approximate numerical and analytical solution procedures.

A.E. 6121. Thermal Effects in Structures II

3-0-3. Prerequisite: E.S.M. 6321 or consent of department.

Analysis of thermally induced stresses in beams, plates and shells, thermally induced instability in columns and plates, reduction in torsional rigidity.

A.E. 6122. Thermal Effects in Structures III

3-0-3. Prerequisite: E.S.M. 6321 or consent of department.

Phenomenological and mechanistic interpretations of

mechanical behavior of solids. Formulation and solution of problems involving elastic, plastic, linear and nonlinear viscoelastic and viscoplastic behavior.

A.E. 6130. Structural Dynamics I
3-0-3. Prerequisite: A.E. 3101, E.S.M. 4210.

Single and multiple degree-of-freedom systems, damping effects, Duhamel superposition integral. Normal modes and equations of motion, Lagrange's equations, methods of obtaining normal modes.

A.E. 6131. Structural Dynamics II
3-0-3. Prerequisite: A.E. 6130.

Vibrations of continuous elastic systems. Stodola and Rayleigh-Ritz methods, Timoshenko beam, longitudinal vibrations. Elastic and plastic waves, analysis of complex structures by modal coupling.

A.E. 6200. Advanced Aeroelasticity I

3-0-3. Prerequisite: A.E. 6030, 6130.

Static aeroelastic analyses of flight vehicles, lifting surface and panel flutter analyses with applications. Dynamic response and load studies of flight vehicles using modal techniques.

A.E. 6201. Advanced Aeroelasticity II

3-0-3. Prerequisite: A.E. 6200.

Formulation of aeroelastic analyses associated with discrete and random dynamic loads, aerodynamic and structural instabilities of fixed- and rotating-wing flight vehicles.

A.E. 6202. Experimental Aeroelasticity

3-0-3. Prerequisite: A.E. 6200.

Analog computing techniques

with applications, flexibility influence coefficient measurements. Vibration testing for modal identification, wind tunnel and inflight flutter tests including model scaling and construction.

A.E. 6203. Special Topics in Aeroelasticity I

3-0-3. Prerequisite: A.E. 6200.

Current topics in aeroelasticity, unsteady aerodynamics and structural dynamics are studied. The student presents both an oral and written report on two specialized current problems.

A.E. 6204. Special Topics in Aeroelasticity II

3-0-3. Prerequisite: A.E. 6200.

Continuation of A.E. 6203. Study of advanced problems in aeroelasticity, unsteady aerodynamics or structural dynamics.

A.E. 6250. Rocket Propulsion I

3-0-3. Prerequisite: A.E. 6260

Flight mechanics, performance of the ideal rocket engine. Properties and performance characteristics of chemical propellants, nozzle designs and losses.

A.E. 6260. Thermodynamics of Gases

4-0-4. Prerequisite: consent of department.

Thermodynamics of reacting gases. Introductory quantum theory, statistical thermodynamics and chemical kinetics.

A.E. 6261. Combustion I

3-0-3. Prerequisite: A.E. 6260 or consent of department.

Introductory chemical kinetics, explosions, Schvab-Zeldovich formulation. Rankine-Hugoniot relations, detonations and deflagrations.

A.E. 6262. Combustion II

3-0-3. Prerequisite: A.E. 6261.

Laminar diffusion flames and droplet burning. Laminar flame propagation in premixed gases, turbulent flames, ignition quenching and flammability limits. Chemical reactions in boundary layers.

A.E. 6300. Meteorology and Atmospheric Dynamics

3-0-3. Prerequisite: consent of department.

Introduction to dynamical and physical processes of natural weather systems, hydrostatic stability and convection, radiation and heat in atmosphere, planned and inadvertent weather modification.

A.E. 6301. Turbulence and Atmospheric Dynamics

3-0-3. Prerequisite: consent of department.

Introduction to turbulence, turbulent transport of momentum and heat, dynamics of turbulence, boundary-free and wall-bounded shear flows, statistical description and spectral dynamics of turbulence.

A.E. 6302. Air Pollution Meteorology

3-0-3. Prerequisite: consent of department.

Fundamentals of air pollution meteorology, engineering approach to atmospheric diffusion, natural removal processes, urban and regional problems, meteorological instruments, air pollution climatology.

A.E. 6303. Atmospheric Boundary Layer

3-0-3. Prerequisite: A.E. 6300 or 6301 or consent of department.

Structure and aerodynamic characteristics of atmospheric

boundary layer, turbulent transport of contaminants in environment, stratified and disturbed atmospheric boundary layer, free-convection layer, current problems.

A.E. 6304. Aerospace Systems and the Environment

3-0-3. Prerequisite: A.E. 6300 or consent of department.

Effects of aerospace vehicle on environment, pollutant emissions from vehicles, chemistry and effects of emissions in troposphere and stratosphere, methods of emission reduction, current problems.

A.E. 6400. Aerodynamics of the Helicopter I

3-0-3. Prerequisite: A.E. 4400.

Forward flight performance, derivation and study of the induced velocity relations and the flow field associated with helicopter rotors.

A.E. 6401. Aerodynamics of the Helicopter II

3-0-3. Prerequisite: A.E. 6400.

Vortex-wake theories for rotors with a finite number of blades, introduction to helicopter stability and control.

A.E. 6460. Aerodynamic Noise

3-0-3. Prerequisite: A.E. 6761.

Jet, boundary layer, combustion, propeller and fan noise. Sonic boom, noise propagation from engines and attenuation techniques.

A.E. 6500. Advanced Stability and Control

3-0-3. Prerequisite: A.E. 4500.

A study of feedback controls as applied to aircraft, root locus techniques and use of airframe transfer functions are emphasized. Survey of the load alleviation problem.

A.E. 6750. System Design Methodology

2-3-3. Prerequisite: graduate standing or consent of department.

Relationship of technological systems to society is studied using economic concepts. Emphasis on the use of engineering type analysis in resolving value laden problems. Examples. Also taught as E.E. 6372, M.E. 6750.

A.E. 6751-2. Complex Systems Design

2-4-3 each. Prerequisite: graduate standing.

This two-quarter sequence permits students from all schools to meet, form an interdisciplinary team and carry out a preliminary design of a significant, complex system. Also taught as E.E. 6751, 6752 and M.E. 6751, 6752.

A.E. 6760. Engineering Acoustics I

3-0-3. Prerequisite: Consent of department.

Introductory analytical methods, stochastic processes, the wave equation in a compressible fluid and problems in the radiation of sound. Also taught as E.S.M. 6760 and M.E. 6760.

A.E. 6761. Engineering Acoustics II

3-0-3. Prerequisite: A.E. 6760.

Sound reflection and refraction, scattering and diffraction, sound radiation and duct acoustics. Also taught as E.S.M. 6761 and M.E. 6761.

A.E. 6762. Engineering Acoustics III

3-0-3. Prerequisite: A.E. 6761.

Advanced duct acoustics, wave dispersion and attenuation, acoustics in moving media, geometrical acoustics, nonlinear acoustics. Also taught as E.S.M. 6762 and M.E. 6762.

A.E. 6763. Noise Reduction and Control (Industrial Applications)

3-0-3. Prerequisites: A.E. 4760 or equivalent and 6760.

Methods of noise reduction and control applied to systems in industry. Measurement of sound power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction and damping methods. Also taught as E.S.M. 6763 and M.E. 6763.

A.E. 6764. Ocean Acoustics

3-0-3. Prerequisite: Geol. 4300 or consent of department, Math. 4321, 4582. A.E. 6760 recommended.

Propagation of sound waves in the oceans, stress-strain relationships, asymptotic ray theory. Propagation in shallow water and deep water. Also taught as E.S.M. 6764, Geol. 6764 and M.E. 6764.

A.E. 7000. Master's Thesis

A.E. 7600. Perturbation Methods in Engineering Analysis

3-0-3. Prerequisite: consent of department.

Regular and singular perturbation theory, WKBJ method and the method of weighted residuals. Problems drawn from fluid mechanics and structures.

A.E. 7750. Bio-Fluid Mechanics

3-0-3. Prerequisite: A.E. 6000 or E.S.M. 6501-2 or consent of department.

A unified treatment on hemorheology, hemodynamics, pulsatile flows, microcirculation, joint lubrication, pulmonary physiology, etc., with emphasis on a quantitative approach. Also taught as E.S.M. 7750.

A.E. 7760. Magnetogasdynamics I
3-0-3. Prerequisite: A.E. 6040 or equivalent.

Fundamental concepts of plasma dynamics, magnetogasdynamic regions motion of charged particles in electromagnetic fields. Debye shielding length, Maxwell transport equations and magnetogasdynamic equations. Also taught as M.E. 7760.

A.E. 7761. Magnetogasdynamics II
3-0-3. Prerequisite: A.E. 7760.

Transport properties of ionized gases, Hall effect, ion slip, electron runaway. Equilibrium and non-equilibrium ionization, magnetoacoustic and Alfvén waves. Magnetogasdynamic shocks, magnetogasdynamic flow phenomena. Also taught as M.E. 7761.

A.E. 7762. Magnetogasdynamics III

3-0-3. Prerequisite: A.E. 7761

Engineering applications of magnetogasdynamics. Magnetogasdynamic power generation, space propulsion, pumps and meters, available experimental data. Characteristics of magnetogasdynamic systems, geophysical and astronomical applications. Also taught as M.E. 7762.

A.E. 7763. Methods of Experimental Magnetogasdynamics
2-3-3. Prerequisite: A.E. 7762.

Laboratory plasma source and flow devices. Theories and applications of plasma diagnostic methods — spectroscopy, microwave interferometry, Langmuir probe, etc. Field trips to representative facilities. Also taught as M.E. 7763.

A.E. 7999. Preparation for Doctoral Qualifying Exams

Noncredit. Prerequisite: consent of director.

A.E. 8000. Seminar

1-0-1.

A.E. 8103-13-23-33-43-53. Special Topics

3-0-3 each. Prerequisite: consent of department.

Special topics of current interest, treatment of new developments in various areas of aerospace engineering.

A.E. 8104-14-24-34-44-54. Special Topics

4-0-4 each. Prerequisite: consent of department.

Special topics of current interest, treatment of new developments in various areas of aerospace engineering.

A.E. 8105-15-25-35-45-55. Special Topics

5-0-5 each. Prerequisite: consent of department.

Special topics of current interest, treatment of new developments in various areas of aerospace engineering.

A.E. 8500-1-2. Special Problems in Aerospace Engineering

Credit to be arranged. Prerequisite: consent of department.

A.E. 8503-4-5. Special Problems in Aerospace Engineering

Credit to be arranged.

A.E. 8999. Preparation for Doctoral Dissertation

Noncredit. Prerequisite: consent of director.

A.E. 9000. Doctoral Thesis

Air Force Aerospace Studies

A.S. 1510. The United States Aerospace Organization and Strategic Offensive Forces 1-1-1.

United States Air Force doctrine, mission and organization, strategic offensive forces covered with emphasis on mission and employment.

A.S. 1520. The United States Aerospace Strategic Defensive and General Purpose Forces 1-1-1.

United States strategic defensive and general purpose forces, emphasis on their mission, employment and the control over employment of nuclear weapons.

A.S. 1530. The United States Aerospace Support and General Purpose Forces. 1-1-1.

Mission, resources and operation of tactical air forces, general-purpose forces and aerospace support forces.

A.S. 2610. Air Power, the Early Years 1-1-1.

A study of the principles of manned flight and doctrine of air power from the 17th century through the 1930's.

A.S. 2620. Air Power, W.W. II to Korea 1-1-1.

An examination of the development of air power doctrines in W.W.II, Berlin airlift and the Korean War.

A.S. 2630. Air Power, the Later Years 1-1-1.

An examination of the role of air power in contemporary times including Middle East, Cuba and Southeast Asia.

A.S. 3211. Military Sociological Aspects 3-1-3.

A study of the environment of current civil-military relations and sociological aspects of the military profession.

A.S. 3212. The Framework and Formulation of Defense Policy 3-1-3.

A study of the requisites for maintaining adequate national security forces with special emphasis upon the impact of political, social and economic constraints on the national defense structure.

A.S. 3213. Actors in the Implementation of Defense Policy 3-1-3.

A study of the impact of technological and international developments on strategic preparedness and the overall policymaking process.

AS. 4110. Air Force Leadership 3-1-3.

Air Force leadership, human relations, and discipline in the military services. Command positions in leadership laboratory.

A.S. 4120. Command-Staff Relationships 3-1-3.

Variables affecting leadership and problem-solving. The commander and his staff. Introduction to Air Force management and military justice.

A.S. 4130. Air Force Management and the Junior Officer
3-1-3.

Functions of management. Air Force personnel policies and information sciences. Briefing for commissioned service.

Architecture

Architecture

Arch. 1001-2-3. Design Fundamentals
1-12-5 each.

Introductory studies in visual and structural expression emphasizing the processes of problem identification, design method and communication.

Arch. 1201-2-3. Architectural History
3-0-3 each.

A study of man's architectural heritage from the beginning of recorded history to the present day. Open to all freshmen.

Arch. 2001-2-3. Architectural Design
1-12-5 each. Prerequisite: Arch. 1003. Corequisite: Arch. 2301-2-3 respectively.

Basic composition, architectural problems and presentation methods, structured to corequisite courses in technical subjects.

Arch. 2301-2-3. Building Anatomy I, II, III
3-0-3 each.

Introduction to building frames, components, and construction techniques, requirements and design of climate control systems, sound and lighting control.

Arch. 2361-2. Color Theory
1-3-2 each.

Lecture and laboratory ex-

periments on the properties of color and its use in design.

Arch. 3001-2-3. Architectural Design

1-12-5 each. Prerequisite: Arch. 2003, 2303. Corequisite: Arch. 3401-21-41, respectively.

Elementary composition, architectural problems and presentation methods, structured to corequisite studies in technical subjects.

Arch. 3201-2-3. History and Theory
3-0-3 each.

History of architecture in ancient Egypt and Mesopotamia, Greece and Rome, Medieval Europe, the Renaissance in continental Europe.

Arch. 3321-2-3. Structures and Materials I, II, III
4-3-5 each. Prerequisite: Arch. 2301, E.S.M. 3702.

Wood, masonry and light-steel frames, steel and reinforced-concrete, integration of steel and concrete, indeterminate structures. Design, application, specification and testing of components.

Arch. 3351. Acoustics of the Built Environment
2-0-2. Prerequisite: Phys. 2113.

The basic principles of and the design approach to the acoustics of buildings and their surroundings.

Arch. 3401-21-41. Urban Planning, Facilities Planning, Building Economics
3-0-3 each.

Survey and historic background of urban planning in the United States: criteria for design and evaluation of buildings, economics of building development, construction and operation.

Arch. 3911-2-3-4. Visual Communication Studios

0-3-1 to 0-15-5.

Introductory studio work in: (1) drawing and painting, (2) sculpture and three-dimensional concepts, (3) photography, (4) graphic design and rendering.

Arch. 4001-2-3. Architectural Design

1-12-5 each. Prerequisite: Arch. 3003.

Intermediate problems in architectural design and presentation methods.

Arch. 4201-2-3. History and Theory

3-0-3 each. Prerequisite: Arch. 3202.

Renaissance architecture in England and America, the 19th and 20th centuries, history of town and city planning in Europe and America.

Arch. 4241-2-3. Art History.

2-0-2.

A survey in the history of artistic manifestations from primitive times to our own day. Open to all students.

Arch. 4244-5. Art History

2-0-2 each.

History of pre-Columbian and oriental art and architecture.

Arch. 4246. Art History

2-0-2. Prerequisite: consent of department.

A survey of 19th and 20th century art in Europe and the United States.

Arch. 4321. Structural Integration

3-3-4. Prerequisite: consent of department.

An integration of information obtained in previous courses in structural design.

Arch. 4401. Introduction to Landscape Architecture

2-0-2.

History of landscape architecture and the study of principles of landscape design as applied to contemporary problems.

Arch. 4421. Housing Seminar

2-0-2.

Lecture and discussion broadly covering the housing field and the home building industry, housing needs, housing markets and financing, standards of design and construction, the government and housing.

Arch. 4551-2. Design

0-27-9 each. Prerequisite: Arch. 4003.

Group 1. Advanced problems in architectural design with emphasis on the solution of complex building programs and site planning.

Arch. 4553. Design

0-27-9. Prerequisite: Arch. 4552, 4561.

Terminal project for the Bachelor of Architecture degree, option I.

Arch. 4554. Design

0-27-9. Prerequisite; Arch. 4003.

Group II. Advanced problems in architectural design with emphasis on structural solutions, computations and details.

Arch. 4555-6. Structural Design

0-27-9 each. Prerequisite: Arch. 4554, 4561.

Terminal project for Bachelor of Architecture, option II.

Arch. 4561-2-3. Seminar

2-0-2 each. Prerequisite: Arch. 4203.

Preparation of thesis program and research, lectures and dis-

cussions of current problems in architectural design and architectural education.

Arch. 4581-2-3. Professional Practice.

3-0-3 each.

Conduct of architectural practice, office organization, competitions, contracts, legal and ethical problems, specification writing, estimating and supervision of construction.

Arch. 4751-2. Psychology of Environmental Design

3-3-4 each. Prerequisite: consent of department.

Course listing and description under Psy. 4751-2.

Arch. 4753. Special Problems in the Psychological Aspects of Environmental Design

Credit to be arranged. Prerequisite: Arch. 4751, 4752.

Course listing and description under Psy. 4753-2-3.

Arch. 4821-2-3. History and Theory

3-0-3 each. Prerequisite: consent of department.

Research in advanced areas of history and theory of architecture.

Arch. 4911-2-3-4. Visual Communications Studios

0-3-1 to 0-15-5.

Intermediate studio work in: (1) drawing and painting, (2) sculpture and three dimensional concepts, (3) photography, (4) graphic design and rendering.

Arch. 4915-6-7-8. Visual Communications Studios

Credit to be arranged. Prerequisite: consent of department.

Self-directed studies in visual communications arts.

Arch. 4951-2-3-4-5. Special Problems.

Credit to be arranged.

Arch. 5644. Cost Analysis

2-3-3. Prerequisite: senior standing.

Principles and methods of cost analysis in the construction industry.

Arch. 6001-2-3. Architectural Design: Special Problems

2-21-9 each. Prerequisite: Arch. 4553 or equivalent.

Solution of a series of advanced problems approved by the committee on design. Subject material determined separately in the case of each candidate to develop his personal talents and general ability, investigation into special areas of architectural design. Research, sketches, presentation drawings, renderings and models, structural synthesis, working details, oral and written reports.

Arch. 6301. Advanced Building Construction

2-3-3.

Folded, saw-tooth, shell, umbrella, and lamella roofs. Bow-string trusses.

Arch. 6321. Membrane Structures in Architecture

3-3-4.

Structural behavior of membrane structures: requirements for stability, dimensional proportions, economic competitiveness and application to architectural problems. Introduction to the analysis of cylindrical shells.

Arch. 6322. Prestressed Concrete Structures in Architecture

3-0-3.

Structural characteristics of prestressed concrete structures,

manufacturing techniques, application to architectural problems, economic factors, principles of analysis and design.

Arch. 6324. Advanced Structural Theory and Design

2-3-3.

Theory of model analysis of structures. Cantilevered, lattice, pin-jointed and rigid frames.

Arch. 6351. Advanced Architectural Acoustics

3-0-3. Prerequisite: Arch. 2303, 3351 or equivalent.

Design requirements for noise control and acceptable room acoustics. Practical design problems, materials selection and calculation of sound propagation parameters.

Arch. 6421. Industrialized Housing

3-0-3.

An examination of the problems and proposed solutions to the design, manufacture, marketing and utilization of industrialized building systems to provide housing.

Arch. 7221. Origin and Evolution of Cities

3-0-3.

Morphological analysis of urban physical settlement patterns. Ecological, social, economic and cultural characteristics as determinants of urban form and structure from prehistory to present.

Arch. 7222. Theories and Principles of Urban Design

3-0-3.

Theories and principles of design revealed through pathological analysis of cities, proposed designs for ideal cities, relevance of psychology and aesthetics as bases for urban design.

Arch. 7401. Urban Design Survey, Analysis and Implementation Methods and Techniques

2-3-3.

Systematic methods for evaluating the built environment and of means to improve its quality. Implementation strategies within the framework of public policy and private decision-making.

Arch. 7402. Urban Design Research

1-6-3.

Independent research for means to improve urban environment. Detailed statement of problem, hypothesis, research methodology and products to be submitted must be approved by staff before enrollment.

Arch. 7804-5-6. Problems in Urban Design I, II, III

2-21-9 each. Prerequisite: Arch. 4553 or equivalent.

Wide range of contemporary urban problems, considerations and judgments at regional, metropolitan/city and sub-city scales. Survey and analysis of new and built environments. Formulation and design of comprehensive land use systems, transportation systems, education, health and open space/recreation systems, and urban services systems. Current and emerging means of plan implementation.

Arch. 8521-2-3. Special Problems in Architectural History

Credit to be arranged.

Individual study of selected periods, architects, schools or building types.

Arch. 8531. Special Problems

Credit to be arranged.

Only for students majoring in structures.

Arch. 8532. Special Problems

Credit to be arranged.

Only for students majoring in structures.

Arch. 8541-2-3. Special Studies in Urban Problems

Credit to be arranged.

Independent study of advocacy planning as a force for improving the quality of the urban environment. Admission to courses permitted upon approval by instructor of applicant's proposed study program.

Arch. 8550. Special Problems

Credit to be arranged.

Building Construction

B.C. 1851. Building Construction Seminar

0-3-1.

Introduction to the field of construction through lectures, discussions, field trips and related reading assignments.

B.C. 2001. Design of Building Systems I

1-12-5. Prerequisite: Math. 1309. Corequisite: Arch. 2301, Phys. 2111.

Design of structural systems for building, analysis of architectural requirements for various types of facilities, comparison of simple structural systems.

B.C. 2002. Design of Building Systems II

1-12-5. Corequisite: Arch. 2302.

Design of climate control systems for buildings, survey of existing facilities as to performance, analysis of architectural problems and requirements for proper climate control systems.

B.C. 2003. Design of Building Systems III

1-12-5. Corequisite: Arch. 2302.

Analysis and design of acoustical and lighting environmental systems for buildings and survey of existing facilities.

B.C. 3301. Construction Practice I

3-0-3. The operation and organization of a construction business.

B.C. 3302. Construction Practice II

3-0-3. Legal limits and statutory requirements for construction.

B.C. 3303. Construction Practice III

3-0-3. Methods and operating procedures of constructing building facilities.

B.C. 3441. Building Production

3-0-3. Processes by which building facilities are produced and delivered.

B.C. 4441. Land Development

3-0-3. Development of land through the best use, highest return and best ecological use.

B.C. 4442. Value Engineering in Construction

3-0-3. Analysis of materials, equipment, facilities, procedures and supplies to achieve lowest possible cost consistent with performance requirements to attain optimum quality in building.

B.C. 4443. Industrial and Construction Safety

3-0-3. The 1970 Occupational Safety

and Health Act as it applies to the building contractor to provide safe working conditions and to the designer to provide safety in buildings.

B.C. 4444. Real Estate Investment
3-0-3.

Real estate as an investment, joint ventures, real estate trusts, financial analysis, tax considerations.

B.C. 4301. Construction Systems
3-0-3.

Construction methods, procedures and systems.

B.C. 4951-2-3. Special Problems in Construction

Credit to be arranged. Prerequisite: senior standing and special permission.

Special problems in construction methods, schedules or management for students in advanced architectural design or construction projects. Research in innovative methods, processes, systems of construction.

City Planning

C.P. 4401. Urban Planning Communication
1-3-2.

Organizing oral presentations, developing speech aids, use of radio, television, conferences and public meetings to communicate planners' ideas.

C.P. 6000. Urban Community Planning
3-0-3.

An orientation to urban and regional planning including organization, functions, techniques and methods of implementation.

C.P. 6010. Land Use Planning
3-0-3.

Factors determining land use, location and interrelationships of various land uses, land use studies and plan preparation, implementation of land use policies and plans.

C.P. 6020. Planning Legislation and Regulation
3-0-3.

Theory and use of eminent domain, taxing and police powers, enabling acts, charters, official maps, codes, restrictive covenants, controlled highway access legislation.

C.P. 6030. Planning Legislation and Regulation
3-0-3.

An intensive study of zoning — its history, principles, uses and limitations through review of significant court cases and subdivision regulations.

C.P. 6040. Resource Development
3-0-3.

A study of natural resources, their adequacy for future needs, influence of technology, evaluation of policies to assure adequate resources for the future.

C.P. 6050. Housing and Urban Renewal
3-0-3.

Urban renewal problems, programs and techniques including legislation, identification of renewal areas, planning, administration, relocation, financing and real estate problems.

C.P. 6060. State and Regional Planning
3-0-3.

Basic concepts and theories of state and regional planning examined in detail. The history,

background, organization and techniques and methods are studied.

C.P. 6070. Public Works Planning I
3-0-3.

Planned change in context of public works planning and development, plan implementation, population analysis, public participation, conflict value assessment and information transfer.

C.P. 6080. Public Works Planning II
3-0-3.

The institutional setting in which public works planning takes place, elements of the planning process and techniques for the assessment of economic, social and environmental impact.

C.P. 6090. Fiscal Aspects of Urban Planning
3-0-3.

Survey of public sector financial planning and management techniques, emphasis on comprehensive planning inputs to public financial policy and operations.

C.P. 6100. Problems in City Planning
2-12-6.

Development of a new town, organization of its government, public and private programs to meet citizen needs, design of new town, preparation and evaluation of plans for specific sites.

C.P. 6110. Problems in City Planning
2-12-6.

Study of existing urban area, preparation of land use and thoroughfare plans including traffic volume estimates, fringe area annexation study, neighborhood conservation plan and program.

C.P. 6120. Problems in City Planning
2-12-6.

An in-depth study on a class basis of a specific urban or regional planning problem prepared for a client agency or citizens organization.

C.P. 6140. Environmental Aspects of City and Regional Planning I
3-0-3.

Identification and quantitative analysis of air, water, noise, spatial pollution and its influence on urban development, health and well-being. Solutions, environmental controls and management programs evaluated.

C.P. 6150 Environmental Aspects of City and Regional Planning II
3-0-3.

Field analysis of noise, air, water and spatial pollution. Students identify, evaluate and apply city planning solutions to environmental problems.

C.P. 6160. Environmental Noise Management
3-0-3.

Management and administration of environmental or community generated noise, analysis of noise impact, noise measurement, instrumentation, rating methods. Evaluation of laws and management programs.

C.P. 6260. Economics of Urban Development
3-0-3.

Economic function of urban communities, location of cities, market analysis and economic feasibility studies of retail stores, offices, hotels, housing and industrial developments and new communities.

C.P. 6270. Economic Analysis of Urban Areas

3-0-3.

An examination of methods and techniques for analyzing the economic base of urban communities, special emphasis on problems of handling population, employment and income data.

C.P. 6280. State and Local Finance

3-0-3.

Extension of C.P. 6090 with emphasis on program design, analysis, operation, evaluation, expenditure and revenue estimates, capital and operating budgets.

C.P. 6290. Economics of Urban Problems

3-0-3.

Seminar on economic and planning aspects of contemporary urban problems, emphasis on student research in particular areas of interest.

C.P. 6350. Introduction to Scientific Methods in Urban and Regional Planning

2-6-4.

Basic concepts of scientific method relevant and applicable to planning practice and theory.

C.P. 6360. Intermediate Scientific Methods in Urban and Regional Planning

2-6-4. Prerequisite: C.P. 6350 or consent of department.

A continuation of 6350, this course covers the intermediate level of modeling and other scientific methods that are relevant and applicable to city planning practice and theory.

C.P. 6370. Systemic Planning Methods in Urban and Regional Planning

2-6-4. Prerequisite: C.P. 6360 or consent of department.

A continuation of C.P. 6360, this course examines the philosophical and intellectual content of the systems approach to city planning.

C.P. 7000. Master's Thesis

Credit to be arranged.

A research problem in city planning, selected by the student in consultation with the graduate staff. Requires one full quarter of work as a minimum with technical direction available from the graduate staff.

C.P. 8010-20-30-40-50. Seminar

1-0-0.

A student-faculty discussion seminar devoted to planning topics in the daily news and the topics of special interest to the group. Visiting lecturers.

Industrial Design**I.D. 1261-2-3. History of Design**

2-0-2 each.

A history of design, technology and innovation, with emphasis on their influence in historic cultures. Open to all students.

I.D. 2001-2-3. Industrial Design

1-12-5 each. Corequisites: I.D. 2301-2-3.

Elements of industrial design, stress on design procedures and problem-solving.

I.D. 2301-2-3. Materials and Process Design

1-3-2 each.

Characteristics of material and production processes, their influence on design: wood, thermoplastics and thermosets.

I.D. 3001-2-3. Industrial Design

1-12-5 each. Prerequisite: I.D. 2003. Corequisites: I.D. 3301-2-3.

Problems of a more complex

nature, emphasizing the human factors in design.

I.D. 3301-2-3. Materials and Process Design

1-3-2 each.

Characteristics of materials and production processes, their influence on design: fibers and ceramics, ferrous and non-ferrous metals.

I.D. 4001-2-3. Industrial Design

1-18-8 each. Prerequisite: I.D. 3003.

Advanced industrial design problems, accentuating individual work in special areas of concentration.

Biology

Biol. 1001. Orientation to Biology
1-0-1.

Orientation to the biology program at Georgia Tech. The nature of biology, contemporary research in biology and career opportunities.

Biol. 1710-1-2. Introduction to Biology I, II, III

3-3-4 each.

For students interested in one year of laboratory science. Principles of genetics, physiology, taxonomy and evolution in plants and animals are discussed. Non-credit for biology majors.

Biol. 2210-1-2. Principles of Biology

4-3-5 each. Prerequisite: Chem. 1112 or 1102 and consent of department; the biology courses to be taken in sequence.

An intensive introduction to the cell integrated into the physiology, genetics development, anatomy and behavior of the intact

organism and the ecology and evolution of populations.

Text: at the level of Villee-Dethier, *Biological Principles and Processes*.

Biol. 3310. General Microbiology

3-6-5. Prerequisite: Biol. 2212, Chem. 3312.

Study of bacteria and other microorganisms.

Text: at the level of Pelczar and Reid, *Microbiology*.

Biol. 3316. Industrial Hygiene

3-0-3.

Problems of health in industry, industrial poisons, occupational hazards and diseases, industrial fatigue, ventilation and accident prevention.

Biol. 3320. Cell Physiology

3-3-4. Prerequisite: Biol. 2212 or equivalent.

Chemical, physical and biological properties of cells. Biological macromolecules, their transformations, metabolism and enzymes. Photosynthesis, protein synthesis and ionic and molecular transport in cells.

Text: at the level of Dowben, *Cell Biology* and selected references.

Biol. 3333. Biostatistics

3-3-4. Prerequisite: Math. 1309, Biol. 2212.

An introduction to statistical methods and their use in the preparation and interpretation of biological experiments.

Text: at the level of Sokal and Rohlf, *Introduction to Biostatistics*.

Biol. 3334. Genetics

3-3-4. Prerequisite: Biol. 2212 or consent of department.

An introduction to the principles of heredity.

Biol. 3335. General Ecology

3-0-3. Prerequisite: either Biol. 1712 or 2212 or consent of department.

Introduction to the concepts of ecology, designed for biology majors but appropriate for interested non-majors. Emphasizes structure and function of natural populations, communities and ecosystems.

Text: at the level of Odum, *Fundamentals of Ecology*, third edition.

Biol. 3336. General Ecology Laboratory

0-3-1. Prerequisite: Biol. 3333 or consent of department; may be taken concurrently with or following Biol. 3335.

Designed to be taken with Biol. 3335. Important aspects of ecological theory, analytical techniques and physical and chemical methods useful in ecological studies.

Text: at the level of Cox, *Laboratory Manual of General Ecology*.

Biol. 3343. Developmental Vertebrate Biology

2-6-4. Prerequisite: Biol. 2212 or equivalent.

Survey of the anatomy, embryology and phylogeny of vertebrate organ systems. Laboratory work involves dissection of adult organism and study of embryological slides.

Biol. 3350. Invertebrate Zoology

3-3-4. Prerequisite: Biol. 2212 or equivalent.

Phylogeny, functional morphology and adaptations of invertebrates, emphasizing broad evolutionary patterns. Dissection, gross examination and field observation of major invertebrate phyla.

Text: at the level of Barnes, *Invertebrate Zoology*.

Biol. 3351. Field Invertebrate Zoology

0-3-1. Prerequisite: Biol. 2212 or equivalent and concurrent enrollment in Biol. 3350.

Field investigations of the biology of invertebrates, including trips to the Atlantic and Gulf coasts.

Biol. 3711. Anatomy and Physiology

3-0-3. Prerequisite: junior standing or consent of department.

Study of human anatomy and fundamental physiological mechanisms. Designed for the advanced student in fields interdisciplinary with the life sciences. Non-credit for biology majors.

Text: at the level of Grollman, *The Human Body*.

Biol. 4407. Advanced Microbiology

3-4-4. Prerequisite: Biol. 3310, Chem 3312.

Advanced discussion and laboratory procedures in bacteriology and general microbiology.

Biol. 4412. Introductory Aerobiology

3-0-3. Prerequisite: Biol. 3310 or consent of department.

Physical and biological factors involved in the dissemination, survival and transport of living microorganisms by the aerial route.

Biol. 4413. Air and Water Pollution

3-0-3. An introduction to the technical and legal problems of air and water pollution by industry and its control, for those engineers working in industry.

Biol. 4415. Introductory Radiation Biology

3-3-4. Prerequisite: consent of department.

A general survey of biological systems and their responses to various kinds of radiations.

Text: at the level of Casarett, *Radiation Biology*.

Biol. 4420. Limnology

3-6-5. Prerequisite: Biol. 3335 or consent of department.

Physics, chemistry and ecology of fresh water. Aquatic communities and ecosystems. Physical, chemical and biological investigation of lakes and streams, including several field trips.

Text: at the level of Reid, *Ecology of Inland Waters and Estuaries*.

Biol. 4423. Population Biology

3-0-3. Prerequisite: Biol. 2211 or consent of department.

Population ecology: dynamics and evolutionary mechanisms including modes of selection and environmental modification of genetic systems.

Text: at the level of Wilson and Bossert, *A Primer of Population Biology*.

Biol. 4425. Marine Population Biology

2-6-4. Prerequisite: introductory courses in ecology, genetics, calculus and biostatistics, or consent of department.

An intensive field experience in theoretical population biology and its relationship to natural marine populations, including sampling techniques, data interpretation and literature review. To be taught at Skidaway Institute of Oceanography.

Text: at the level of Wilson and Bossert, *A Primer of Population*

Biology and Ford and Hazen, Readings in Aquatic Ecology.

Biol. 4431. Cytology

3-6-5. Prerequisite: Biol. 2212.

Modern aspects of the morphologic, functional and cytochemical organization of the cell. Preparative techniques and principles for observations in light, phase and electron microscopy.

Biol. 4435-6. Applied Biology

3-0-3 each. Prerequisite: consent of department.

Selected topics in modern biology.

Biol. 4443. General Animal Physiology I

3-6-5. Prerequisite: Biol. 3320, Chem. 3312 or consent of department.

Vertebrate systems physiology to include: muscles, nerves, circulation, respiration and body fluids.

Biol. 4444. General Animal Physiology II

3-6-5. Prerequisite: Biol. 3320, Chem. 3312 or consent of department.

Continuation of Biol. 4443, to include the following: renal systems, special senses, digestion, absorption, reproduction and the endocrine system. It is recommended but not mandatory that Biology 4443 be taken prior to Biology 4444.

Biol. 4445. Plant Physiology

3-6-5. Prerequisite: Biol. 3320, Chem. 3312 or consent of department.

Chemical transformations in photosynthesis, photophysiology and water relationships in organic nutrition and effect of hormones on growth and development.

Biol. 4450. Seminar

2-0-2. Prerequisite: normally taken by seniors.

Student and staff presentations of reports on laboratory or literature searches.

Biol. 4461. Cytogenetics

3-6-5. Prerequisite: Biol. 3334, 4431.

A correlated study of genetics and cytology primarily concerned with the chromosomal basis of genetics. Laboratory experience in methodology of chromosome study including humans.

Texts: at the level of Brown, *Textbook of Cytogenetics* and Bur-nam, *Discussions in Cytogenetics*.

Biol. 4464. Developmental Genetics

3-0-3. Prerequisite: Biol 3334 or consent of department.

Transcriptional, translational and post-translation control of gene expression in cell differentiation, mechanisms of genomic regulation in eukaryotes, nucleocytoplasmic interactions, genetic aspects of morphogenesis.

Biol. 4466. Genetics of Populations

3-0-3. Prerequisite: Biol. 3334 or consent of department.

Factors determining gene frequency equilibria and changes in populations: selection, mutation, genetic drift, inbreeding, heritability and the nature of genetic variation.

Text: at the level of Mettler and Gregg, *Population Genetics and Evolution*.

Biol. 4468. Molecular Genetics

3-3-4. Prerequisite: Biol. 3334.

Molecular genetics, with special emphasis on the study of nucleic acid structure and function and

bacterial and viral structure and function.

Text: at the level of Watson, *Molecular Biology of the Gene*.

Biol. 4476. Multi-molecular Biology

3-0-3. Prerequisite: Biol. 2212, Chem. 3313 and Phys. 2123 or consent of department.

Structure, formation and properties of biological objects at a level of organization between single molecules and cells.

Biol. 4478. Physical Biology

4-0-4. Prerequisite: Phys. 2121, Chem. 3312 or consent of department.

Use of physics and biochemistry in explaining structure and function of biological systems at atomic and molecular levels. Approach mathematical, quantum mechanics introduced as needed.

Text: at the level of Setlow and Pollard, *Molecular Biophysics*.

Biol. 4774. Applications of Microbiology in Sanitary Engineering

3-3-4. Prerequisite: senior standing, fall quarter.

Microbiology in environmental engineering. Relationships of protozoa, algae, bacteria and viruses to water borne disease, the treatment of wastes and the deterioration of aquatic habitats.

Biol. 4960-1-2. Special Problems

Hours to be arranged. Prerequisite: Biol. 2212.

Special laboratory problems in biology, to be given any quarter with credits (not to exceed six) to be arranged.

Biol. 6619. Ecological Systems

3-0-3. Prerequisite: consent of department.

Ecosystem structure and function. Fundamentals of ecology, approaches and problems associated with analysis of ecosystems. Applications of systems analysis to aquatic and terrestrial ecosystem models.

Biol. 6622. Special Topics in Ecology

1-2-2. Prerequisite: Biol. 6619 or consent of department.

Topics of current interest in environmental science such as systems analysis, indicators of pollution, environmental impact evaluation and environmental monitoring.

Biol. 6632. Design of Experiments in Quantitative Biology

3-3-4. Prerequisite: Biol. 3333.

The philosophical and statistical basis for design of experiments in biology. Selected examples from the research of individual staff members will serve to demonstrate the basic principles.

Text: at the level of Wilson, *An Introduction to Scientific Research*.

Biol. 6633. Selected Topics in Radiobiology

3-3-4. Prerequisite: Biol. 4415.

High-energy radiation as an investigative tool including determination of cell structure and function, target theory and multihit phenomena.

Biol. 6634. Selected Topics in Experimental Cell Biology

3-3-4. Prerequisite: Biol. 6633.

Research areas in microbiology and mammalian cell culture, including permeability of cell membranes, cytogenetics and selection pressures in cell cultures.

Biol. 6635. Air Pollution Biology

3-0-3. Prerequisite: consent of department.

Designed to acquaint engineers and scientists with the biological aspects of air pollution as one factor in the total environment of living animals and plants.

Biol. 6640. Instrumental Methods in Biology

3-6-5. Prerequisite: consent of department.

Biophysical and biochemical methods for the study of macromolecules, cell components, multicellular and organism level organization. Analysis by electron microscopy, spectroscopy, centrifugation and other methods.

Biol. 6641. Electron Microscopy Laboratory

0-6-2.

Techniques for the fixation, lyophilization, staining and sectioning of biological materials.

Biol. 6646. Mammalian Physiology

3-3-4. Prerequisite: Biol. 4444 or equivalent or consent of instructor.

Physical, biochemical and biological phenomena underlying organ functions. Integration of physiological processes and basic techniques of physiological analysis.

Biol. 6647. Developmental Physiology

3-6-5. Prerequisite: Biol. 3343, 4444 or equivalents or consent of instructor.

Fetal and maternal organ function, vertebrate organogenesis. Investigations of organogenesis in laboratory animals and of abnormal development induced by teratogenic agents.

Biol. 6648. Mammalian Endocrinology

3-0-3. Prerequisite: Biol. 2212, Chem. 3511 or consent of department.

Systematic treatment of the mammalian endocrine system, including mechanisms of hormone action, methods of hormonal assay, endocrine histology and relationships between neural and endocrine integration.

Text: at the level of Sawin, *The Hormones*.

Biol. 6649. Neurobiology

3-0-3. Prerequisite: Chem. 3313, Phys. 2123, Biol. 2212 or consent of department.

A survey of some of the basic mechanisms of neural function and methods used to study them, with particular reference to the visual system.

Texts: at the level of Katz, *Nerve, Muscle, and Synapse*, selections from Schmitt, *The Neurosciences*, *Second Study Program*, and references.

Biol. 6664. Selected Topics in Regulatory Biology

3-0-3. Prerequisite: Biol. 3334, Chem. 3351 or consent of department.

"Second messengers," cyclic AMP-prostaglandin interactions, positive and negative transcriptional control in prokaryotes, cyclic AMP and catabolite repression, transcriptional regulation in eukaryotes.

Biol. 6711. Medical Physiology

5-0-5. Prerequisite: graduate standing, introductory biology or consent of department.

Systematic study of mammalian and particularly of human physiology and essential anatomy, designed for advanced students in fields interdisciplinary with the life sciences. Credit not available for biology majors.

Text: at the level of Ganong, William F., *Review of Medical Physiology*.

Biol. 6730. Biological Effect of Radiations

3-3-4. Prerequisite: consent of department.

An introduction to the effects of nuclear radiations upon biological systems for graduate students in the nuclear science and engineering curriculum.

Biol. 7000. Thesis

Biol. 8043-4-5. Seminar in Physiology

2-0-2 each. Prerequisite: graduate standing.

Current concepts of membrane structure, molecular and ionic transport mechanisms, endocrinology, cardiac, nervous and muscular function, physiology of development. Student and faculty presentations.

Biol. 8063-4-5. Seminar in Genetics

2-0-2 each. Prerequisite: graduate standing.

Topics of current interest in the areas of cytogenetics, developmental genetics, molecular genetics, mutagenesis and the genetics of man and populations. Student and faculty presentations.

Biol. 8504-5-6. Special Problems

Credit to be arranged.

Ceramic Engineering

Cer. E. 1010. Introduction to Ceramic Engineering

2-3-3. Elective for freshmen.

A comprehensive survey of ceramic materials, raw materials and the industrial processes used in their production.

Text: at the level of Mitchell, *Ceramics - Stone Age to Space Age*.

Cer.E. 3001. Ceramic Data Handling
2-3-3.

Study of testing, rational economic value of tests results, basis of test selection, interpretation of results, data analysis, statistical methods, computer methods, reporting.

Text: at the level of Bivington, *Data Reduction and Error Analysis for the Physical Sciences* and Holscher, *Simplified Statistical Analysis*.

Cer. E. 3002. Properties of Engineering Materials

2-3-3. Prerequisite: Chem. 1101 or equivalent.

Introduction to types of materials available to engineers, their properties, the causes of these properties and how these properties determine their utilization and service life.

Text: at the level of Van Vlack, *Elements of Materials Science* and Kingery, *Introduction to Ceramics*.

Cer. E. 3003. Ceramic Processing I

3-3-4. Prerequisite: Chem. 1102 or equivalent.

Processing of ceramic articles based on clay and clay minerals or plastic forming processes.

Text: at the level of Jones, *Ceramics*.

Cer. E. 3004. Ceramic Processing II

2-3-3. Prerequisite: Cer. E. 3003.

Forming processing of non-plastic technical and fine-grained ceramic materials.

Text: at the level of Kingery, *Ceramic Fabrication Processes*.

Cer. E. 3005. Phase Equilibria for Ceramists

3-0-3. Prerequisite or corequisite: Chem. 3411.

Interpretation of phase equilibria in non-metallic high temperature one, two and three component systems. Usefulness of phase diagrams in the processing of ceramic materials considered.

Text: at the level of Levin, Robbins and McMurdie, *Phase Diagrams for Ceramists* (monography by the American Ceramic Society).

Cer. E. 3006. Physical Ceramics I
3-0-3. Prerequisite: Cer. E. 3002.

Crystal chemistry concepts are developed and used to characterize silicate, oxide and nonoxide ceramic materials.

Text: at the level of Kingery, *Introduction to Ceramics*.

Cer. E. 3007. Pyrometry and Thermal Analysis

2-3-3. Prerequisite: Phys. 2122.

Temperature measurement using thermocouples, optical pyrometers and radiation pyrometers is emphasized. Differential thermal analysis and thermogravimetric analysis in characterizing ceramic materials is presented.

Text: at the level of *Precision Measurement and Calibration*: volume two, *Temperature*, NBS Special Publication 300.

Cer. E. 3008. Glass Technology I

2-3-3. Prerequisite: Cer. E. 3005 or consent of school.

The fundamentals of glass structure, composition, manufacturing, properties and applications are described. In the laboratory many glass batches are melted and analyzed.

Text: at the level of Hutchins and Harrington, *Glass*, (reprint from volume 10, *Encyclopedia of Chemical Technology*, second edition, pp. 533-604, J. Wiley, 1966).

Cer. E. 3080. Survey of Ceramics
2-0-2.

General elective for non-majors. A survey of the classifications and physical properties of ceramic products, the materials and manufacturing processes.

Text: at the level of Mitchell, *Ceramics - Stone Age to Space Age*.

Cer. E. 3090. Ceramic Survey Laboratory

0-3-1. Prerequisite or corequisite: Cer. E. 3080.

General elective. Plant trips to local ceramic plants, flowsheets of processes, production of simple pottery and ceramic pieces.

Cer. E. 4002. Refractories and Combustion

3-3-4. Prerequisite: Cer. E. 3006, Chem. 3412.

Fundamentals of refractory material selection and application are stressed. The raw materials for manufacturing refractories and the engineering of refractory walls are covered.

Text: at the level of Shaw, *Refractories and Their Uses*, and Anon, *North American Combustion Handbook*.

Cer. E. 4003. Physical Ceramics II
2-3-3. Prerequisite: Cer. E. 3006, Phys. 2123, Chem. 3413.

Densification, sintering and reaction kinetics active in ceramic materials are considered. The resultant physical, mechanical, electric and magnetic properties are related to the atomic and macroscopic structure representative of ceramic products.

Text: at the level of Kingery, *Introduction to Ceramics*.

Cer. E. 4004. High Temperature Thermodynamics

2-0-2. Prerequisite: Chem. 3412.

Chemical thermodynamics data is used to predict reaction directions and study vaporization processes. The use of various gas mixtures to control oxygen pressures is also described.

Text: at the level of Wicks and Block, *Thermodynamic Properties of 65 Elements - Their Oxides, Halides, Carbides and Nitrides*. Bureau of Mines Bulletin No. 605 (1963).

Cer. E. 4005. Glass Technology II

2-3-3. Prerequisite: Cer. E. 3008.

Compositions of low, moderate and high temperature coatings are studied to learn basis of glass properties, adherence, color, opacification and texture.

Text: at the level of C.W. Parmelee, *Ceramic Glazes*.

Cer. E. 4010-1-2. Technical Management and Design Problems

1-3-2, 0-6-2, 0-3-1. Prerequisite: consent of school.

Major experimental or equipment design is selected by class from a number of problem areas presented by industry.

Cer. E. 4015. Independent Research Project I

1-0-1. Prerequisite: senior standing in ceramic engineering.

The object of this course is to place the student on his own initiative and to coordinate the knowledge that he has previously received.

Cer. E. 4016. Independent Research Project II

1-3-2. Prerequisite: Cer. E. 4015.

The senior student formulates an experimental plan under super-

vision of instructor, assembles equipment and materials and begins actual laboratory experimentation.

Cer. E. 4017. Independent Research Project III

0-6-2. Prerequisite: Cer. E. 4016.

Completion of all laboratory work on investigation, submission of approved write-up in acceptable format one week before examination week.

Cer. E. 4018. Drying and Psychrometry

2-0-2. Prerequisite: Phys. 2122.

Fundamental consideration of water removal from unfired ceramic products by heat and air.

Text: at the level of Moody, *Drying*.

Cer. E. 4042-3-4. Seminar

1-0-1. Prerequisite: junior standing.

Discussion of current ceramic and scientific literature and reports of investigations.

Cer. E. 4051. Cements

2-3-3. Prerequisite: Cer. E. 3005.

Includes the required properties of raw materials, processing and the hydraulic properties of cements. Portland, magnesia, high alumina, dental and gypsiferous cements are included.

Text: at the level of Bogue, *The Chemistry of Portland Cement* or Lea, *The Chemistry of Cement and Concrete*.

Cer. E. 4052. Inorganic Phase Analysis and Identification

3-3-4. Prerequisite: Phys. 2122.

Provides the student with the tools to identify a ceramic material using both atomic structure related techniques and elemental identification. Use of optical

crystallograph, x-ray diffraction, transmitted and reflected light microscopy and electron microscopy are emphasized as tools to identify ceramic material phases and elemental composition.

Text: at the level of Bloss, *An Introduction of the Methods of Optical Crystallography* and Culley, *Elements of X-ray Diffraction*.

Cer. E. 4053. Technical Ceramics

2-3-3. Prerequisite: Cer. E. 3006, Phys. 2122.

Frabrication requirements, property control and structure — property — processing relationships, ceramic dielectrics, ferrites, ferroelectrics, piezoelectrics emphasized.

Text: at the level of F. H. Norton, *Fine Ceramics* and E. C. Henry, *Electronic Ceramics*.

Cer. E. 4801-2-3-4-5. Special Topics

Credit by arrangement (1,2,3,4 or 5 hours). Prerequisite: consent of school.

New developments in ceramic materials, specialized independent study on topics of current interest.

Cer. E. 6011. Colloidal Properties of Hydrous Alumino Silicates

3-0-3. Prerequisite: consent of department.

The physiochemical properties of the plastic and non-plastic hydrous alumino silicate are studied including viscosity, dispersion, flocculation and permeability.

Text: at the level of Van Olphen, *An Introduction to Clay Colloid Chemistry*.

Cer. E. 6012. Colloidal Properties of Hydrous Alumino Silicates

3-3-4. Prerequisite: consent of department.

Plastic properties of clay-water systems and industrial applications. Interactions of clays and organic compounds.

Text: at the level of Lawrence, *Clay-Water Systems*.

Cer. E. 6013. Colloidal Properties of Hydrous Alumino Silicates

3-0-3. Prerequisite: consent of department.

Basic surface properties are studied for application to gas adsorption surface area measurements and mineral flotation processes.

Cer. E. 6014-5. Ceramic Applications to the Phase Rule

3-0-3 each. Prerequisite: Cer. E. 3005 or consent of department.

Phase equilibria in one, two and three-component systems reviewed. Melting and solidification behavior in complex three-component systems examined. Effect of oxygen pressure on phase relations in multi-component systems surveyed. Applications of thermodynamics to phase diagrams.

Text: at the level of Prince, *Alloy Phase Equilibria*.

Cer. E. 6017-8. Glass Technology

3-0-3 each.

Constitution of glass is studied using dynamic considerations. The reasons for the failure of oxide melts to crystallize on cooling are emphasized. Mutual polarization of ions is utilized in analyzing the various glass structures. The different experimental techniques available to study glasses are reviewed.

Text: at the level of Weyl and Marboe, *The Constitution of Glasses: A Dynamic Interpretation*.

Cer. E. 6030. Crystal Structure of Materials

3-0-3. Prerequisite: consent of department.

Basic crystal structures and relation of different chemical compounds with similar crystal structures. Structures of various clays and complex oxides.

Text: at the level of Evans, *Crystal Chemistry* and Wells, *Structural Inorganic Chemistry*.

Cer. E. 6031. Crystal Structure of Materials

3-0-3. Prerequisite: consent of department.

Relationship of crystal structure to chemical, physical and optical properties of high temperature inorganic materials.

Cer. E. 6035. Research and Control Methods

2-3-3. Prerequisite: consent of department.

Emphasis on the experimental and instrumental techniques for research and control measurements. Review of optical, physical, electrical, mechanical measurement techniques, instrumentation, laboratory demonstrations.

Text: at the level of Wilson, *Introduction to Scientific Research* and Ackoff, *Scientific Method*.

Cer. E. 6040. Crystal Studies I

2-3-3. Prerequisite: Cer. E. 4025 or consent of department.

Fundamentals, methods and instruments in applications of x-ray diffraction, especially the powder method, to problems in ceramics and metallurgy.

Text: at the level of Azaroff, *Elements of X-ray Crystallography*.

Cer. E. 7000. Master's Thesis

Cer. E. 8001-2-3-4-5-6. Seminar 1-0-0.

Current ceramic developments.

Cer. E. 8102 through 8119. Special Topics

Credit to be arranged.

Specific, well-defined study and measurement problems will be considered and approved for credit upon completion.

Cer. E. 8501-2-3. Special Problems

Credit to be arranged.

Cer. E. 9000. Doctoral Thesis

Chemical Engineering

Chemical Engineering

Ch.E. 1101. Introduction to Chemical Engineering

1-0-1.

An orientation to chemical engineering. Nature of chemical engineering, the types of opportunities available and the requirements for graduation and a successful career.

Ch.E. 1110. Elements of Chemical Engineering Design

2-3-3.

An introduction to chemical engineering design in which simplified problems of current interest are discussed in the lectures and demonstrated in the laboratory.

Text: at the level of Badger and Banchero, *Introduction to Chemical Engineering*.

Ch.E. 2207-8. Chemical Process Principles I, II

3-0-3 each. Prerequisite or corequisite: Chem. 2113, Math. 1309.

Stoichiometric principles, physical and chemical properties, thermophysics and thermochemistry leading to rather detailed material and energy balances on chemical, metallurgical and petroleum processes.

Text: at the level of Himmelblau, *Basic Principles and Calculations in Chemical Engineering*.

Ch.E. 2209. Computers in Chemical Engineering

2-3-3. Prerequisite: Math. 2308. Prerequisite or corequisite: Ch.E. 2208.

A study of the application of digital and analog computers to the solution of chemical engineering problems.

Text: at the level of Peterson, *Analog Computation* and Murill and Smith, *Fortran IV, Programming for Engineers and Scientists*.

Ch.E. 3304. Transport Phenomena I

3-3-4. Prerequisite: Math. 2308. Prerequisite or corequisite: Ch.E. 2209.

Fundamental principles of momentum and energy transfers are developed. Application of these principles are stressed.

Text: at the level of Bird, Stewart and Lightfoot, *Transport Phenomena*.

Ch.E. 3305. Transport Phenomena II

3-3-4. Prerequisite: Ch.E. 3304.

The development of Ch.E. 3304 is extended to include mass transfer. Major emphasis is placed on applications involving heat and mass transfer.

Text: at the level of Bird, Stewart and Lightfoot, *Transport Phenomena*.

Ch.E. 3306. Unit Operations I

3-0-3. Prerequisite: Ch.E. 3304. Prerequisite or corequisite: Ch.E. 3305.

The analysis of chemical engineering processes and operations involving fluid and heat transfer.

Text: at the level of McCabe and Smith, *Unit Operations of Chemical Engineering* and Perry, *Chemical Engineer's Handbook*.

Ch.E. 3315. Unit Operations II

3-3-4. Prerequisite: Ch.E. 3304. Stagewise operations.

Text: at the level of McCabe and Smith, *Unit Operations of Chemical Engineering* and Perry, *Chemical Engineer's Handbook*.

Ch.E. 3339. Chemical Engineering Literature

1-0-1. Prerequisite: Ch.E. 3304, Chem. 3311, 3411.

Training of students in the use of sources of chemical and chemical engineering information. Use of the library. Literature searching.

Ch.E. 3700. Elementary Heat and Mass Transfer.

3-0-3. Prerequisite: Math. 2308, Phys. 2123, M.E. 3720 and senior standing or consent of school.

Elementary heat and mass transfer primarily designed for textile students. Not open to students in the School of Chemical Engineering.

Text: at the level of McCabe and Smith, *Unit Operations of Chemical Engineering*.

Ch.E. 4111. Mineral Resources II: Fossil Fuels

3-0-3.

An introductory course in fossil fuels. Gives majors in engineering a background in fuels as raw materials.

Ch.E. 4407. Chemical Process Analysis

3-0-3. Prerequisite: Ch.E. 3315, Chem. 3313, 3413.

Introduction to the engineering of chemical reactions involving colloidal and amorphous materials.

Text: at the level of Adamson, *Physical Chemistry of Surfaces*, second edition, and Rodriguez, *Principles of Polymer Systems*.

Ch.E. 4413. Unit Operations III

3-3-4. Prerequisite: Ch.E. 3305

Diffusional processes, including combined mass and heat transfer.

Text: at the level of Perry, *Chemical Engineer's Handbook* and McCabe and Smith, *Unit Operations of Chemical Engineering*.

Ch.E. 4414. Air Pollution Control

3-0-3.

Application of mass transfer principles to the design of pollution control systems utilizing adsorption, absorption, filtration and precipitation. Other topics are process optimization, fuel pretreatment.

Text: at the level of Strauss, *Air Pollution Control*.

Ch.E. 4415. Reactor Design

3-0-3. Prerequisite: Ch.E. 3315, Chem. 3313, 3413.

Kinetics and mechanisms of industrial chemical reactions. Effects of temperature, pressure and concentrations on the rates of chemical reactions. Design of batch backmix, tubular and semi-batch reactors.

Text: at the level of Levenspiel, *Chemical Reaction Engineering*.

Ch.E. 4416 Process Control

3-3-4. Prerequisite: Ch.E. 3305. E.E. 3700 recommended.

Dynamics of chemical processes and theory of control techniques. Mathematics using primarily Laplace transforms is applied with instrumentation and process constraints to system design.

Text: at the level of Weber, *An Introduction to Process Dynamics and Control*.

Ch.E. 4431. Chemical Engineering Economics
3-0-3.

A study of techniques required in project analysis in areas of systems cost analysis and the use of the economic balance for design and optimization.

Text: at the level of Peters and Timmerhaus, *Plant Design and Economics for Chemical Engineers*.

Ch.E. 4432. Process and Equipment Design

2-3-3. Prerequisite or corequisite: Ch.E. 4431, Met. 3301.

Comprehensive problems for each of the basic types of chemical process equipment solved. Pressure vessels, heat exchangers, mass transfer equipment and materials handling equipment.

Text: at the level of Peters and Timmerhaus, *Plant Design and Economics for Chemical Engineers*.

Ch.E. 4434. Chemical Plant Design

1-6-3. Prerequisite: Ch.E. 3339, 4413, 4415, 4416, 4431, 4432, 4438.

A comprehensive problem in plant design.

Ch.E. 4438. Chemical Engineering Thermodynamics

4-0-4. Prerequisite: Chem. 3412, Ch.E. 3315.

Principles of thermodynamics with industrial applications. Flow of compressible fluids, thermodynamic properties, charts, tables, power and refrigeration cycles and processes, phase equilibria, chemical equilibria.

Text: at the level of Smith and Van Ness, *Introduction to Chemical Engineering Thermodynamics*.

Ch.E. 4449. Computer Aided Process Design

2-3-3. Prerequisite: Ch.E. 3306, 4413, 4415 or consent of school.

A study of the synthesis and operation of large-scale computer systems for steady-state simulation of chemical processes as a design tool.

Text: at the level of Crowe et al., *Chemical Plant Simulation*.

Ch.E. 4453. Polymerization Process Analysis

3-0-3. Prerequisite: Met. 3301, Ch.E. 4415 or consent of school.

Polymerization processes are analyzed with regard to reaction mechanisms, kinetics and reactor design. Methods of controlling polymer structure during polymerization are emphasized.

Ch.E. 4455. Plastics Industry Manufacturing Policy

3-0-3. Prerequisite: consent of school.

Case studies of practical problems contributed by industry concerning plastics manufacturing, marketing and management. Decision-making processes in the plastics industry are emphasized.

Text: at the level of Skinner and Rogers, *Manufacturing Policy in the Plastics Industry*.

Ch.E. 4501. Pulp and Paper Processes I

3-0-3. Prerequisites: consent of school.

A survey of the processes in a kraft pulp and paper mill necessary to convert raw material into finished product. The chemical and mechanical characteristics of kraft pulping, bleaching and chemical recovery processes.

Ch.E. 4502. Pulp and Paper Processes II

3-0-3. Prerequisites: consent of school.

The major pulping processes other than kraft pulping. General knowledge of the various factors affecting each pulping process. The unique advantages and disadvantages of each pulping process.

Ch.E. 4503. Pulp and Paper Mill Emission Control.

3-0-3. Prerequisites: consent of school.

Methods for control of gaseous, liquid and solid wastes from pulp and paper mill operations. Major biological, chemical and physical methods for treatment of waste streams.

Ch.E. 4750. Polymer Science and Engineering I

3-0-3. Prerequisite: Chem. 1102, Phys. 2123.

An introduction to the chemistry and structure of polymers. Polymerization processes, major polymer systems and methods of polymer identification are presented. Also taught as Text. 4750.

Text: at the level of Rodriguez, *Principles of Polymer Systems*.

Ch.E. 4751. Polymer Science and Engineering II

3-0-3. Prerequisite: Ch.E. 4750.

An introduction to the physical states and transitions, fabrication processes and mechanical properties of polymers. Also taught as Text. 4751.

Text: at the level of Rodriguez, *Principles of Polymer Systems*.

Ch.E. 4752. Polymer Science and Engineering Laboratory

0-3-1. Prerequisite or corequisite: Ch.E. 4751.

Experiments in polymerization, processing and property evaluation of polymers. Also taught as Text. 4752.

Ch.E. 4753. Survey of Pulp and Paper Technology

3-0-3.

A survey is made of the mechanical systems used in paper manufacture. The chemistry of pulp preparation and non-fibrous additives is outlined. Also taught as Text. 4753.

Ch.E. 4901-2-3. Special Problems

Credit to be arranged. Prerequisite: Ch.E. 3305.

The student is given an opportunity to develop initiative and to apply fundamental principles by doing semi-original laboratory investigation of a chemical engineering research nature.

Ch.E. 6601. Chemical Engineering Thermodynamics I

3-0-3. Prerequisite: Ch.E. 4438 or consent of school.

The laws of thermodynamics with particular application to pure substances. Equations of state, thermodynamic functions of gases and liquids, thermodynamic charts and networks, engineering applications.

Ch.E. 6602. Chemical Engineering Thermodynamics II

3-0-3. Prerequisite: Ch.E. 6601 or consent of school.

Thermodynamics of solutions. Ideal and non-ideal nonelectrolyte solutions. Phase equilibria involving gas, liquid and solid phases. Molecular properties of liquid and liquid mixtures. Engineering applications.

Ch.E. 6603. Chemical Engineering Thermodynamics III

3-0-3. Prerequisite: Ch.E. 6602 or consent of school.

Thermodynamic equilibrium including chemical equilibrium. Statistical thermodynamics. Third law of thermodynamics. Heat capacities at low and high temperatures. Ionic solids and solutions. Engineering applications.

Ch.E. 6604-5-6. Organic Chemical Technology

3-0-3 each. Prerequisite: Chem. 3313.

Important organic chemical processes and their combinations are studied with emphasis on more recent developments.

Ch.E. 6610. Aerosol Technology

3-0-3. Prerequisite: consent of school.

Presents basic concepts describing the behavior of dispersed particles. Includes generation, sampling and size analyses, diffusion, coagulation, settling, kinetics and dynamics, electrostatic and optical properties.

Ch.E. 6611. Industrial Emission Control

3-0-3. Prerequisite: consent of school.

Air quality criteria, ambient and emission standards and industrial

sources are analyzed. Recovery and utilization of waste gaseous and particulate matter is presented.

Text: at the level of Strauss, *Air Pollution Control*.

Ch.E. 6612. Atmospheric Reactions

3-0-3. Prerequisite: consent of school.

The principles of atmospheric chemical and photochemical reactions, including primary and derived air pollutants, sources and sinks of carbon, nitrogen, sulfur and oxygen compounds.

Text: at the level of Butcher and Charlson, *An Introduction to Air Chemistry*.

Ch.E. 6613. Technology of Fine Particles

3-0-3. Prerequisite: Ch.E. 3305 or consent of school.

An examination of the properties of finely divided materials. Size, surface, pores are treated in relation to reactivity, adsorptivity, catalytic behavior and process engineering operations.

Text: at the level of Gregg and Sing, *Adsorption Surface Area and Porosity*.

Ch.E. 6615. Transport Phenomena I

3-0-3. Prerequisite: Ch.E. 3305 or consent of school.

Advanced theory and applications of momentum transport.

Text: at the level of Bird, Stewart and Lightfoot, *Transport Phenomena*.

Ch.E. 6616. Transport Phenomena II

3-0-3. Prerequisite: Ch.E. 6615 or consent of school.

Advanced theory and

applications of energy transport.

Text: at the level of Bird, Stewart and Lightfoot, *Transport Phenomena*.

Ch.E. 6617. Transport Phenomena III

3-0-3. Prerequisite: Ch.E. 6616 or consent of school.

Advanced theory and applications of mass transport.

Text: at the level of Bird, Stewart and Lightfoot, *Transport Phenomena*.

Ch.E. 6619. Chemical Engineering Calculations I

3-0-3. Prerequisite: Ch.E. 4413, Math. 2309.

A study of the application of classical mathematical methods (including Laplace transforms and Bessel functions) to the solution of typical chemical engineering problems.

Text: at the level of Mickley, Sherwood and Reed, *Applied Mathematics in Chemical Engineering*.

Ch.E. 6620. Chemical Engineering Calculations II

3-0-3. Prerequisite: Ch.E. 6619 or consent of school.

A study of the application of modern mathematical techniques (including numerical methods and optimization procedures) to the solution of typical chemical engineering problems.

Text: at the level of Mickley, Sherwood and Reed, *Applied Mathematics in Chemical Engineering*.

Ch.E. 6622. Advanced Reactor Design

3-0-3. Prerequisite: Ch.E. 4415.

A study of chemical kinetics and mechanisms in complex homogeneous and heterogeneous reaction systems. Design of

chemical reactors for such systems.

Text: at the level of Smith, *Chemical Engineering Kinetics*.

Ch.E. 6624. Introduction to Cryogenics

3-0-3. Prerequisite: Ch.E. 6603 or consent of school.

Thermal, mechanical, electrical, magnetic and chemical properties of matter from room temperature to 0°K. Applications to cryogenic processes. The emphasis will vary from year to year.

Ch.E. 6628. Advanced Unit Operations I

3-0-3. Prerequisite: Ch.E. 4413.

Flow through conduits, metering of fluids, mixing of liquids, flow and heat transfer in heat exchangers, packed columns and fluidized beds.

Ch.E. 6629. Advanced Unit Operations II

3-0-3. Prerequisite: Ch.E. 4413.

Thermal radiation in furnaces, measurement of elevated temperatures, condensation of mixed vapors and evaporation.

Text: at the level of McAdams, *Heat Transmission*.

Ch.E. 6633. Inorganic Chemical Technology

3-0-3. Prerequisite: consent of school.

Technology of selected inorganic processes and industries, especially the ammonia, nitric acid, ammonium nitrate, urea, phosphoric acid, ammonium phosphate, superphosphate and potash industries.

Ch.E. 6635. Advanced Unit Operations III

3-0-3. Prerequisite: Ch.E. 4413.

Vapor liquid equilibrium and separation by distillation of binary

and multicomponent mixtures. Factors influencing design and performance of fractionating equipment. Application of azeotropic and extractive distillation.

Text: at the level of Robinson and Gilliland, *Elements of Fractional Distillation*.

Ch.E. 6637. Advanced Unit Operations IV

3-0-3. Prerequisite: Ch.E. 4413 or consent of school.

An advanced study of absorption and stripping in simple and in multicomponent systems. Designs and performance of equipment. Solid-liquid and liquid-liquid extraction.

Ch.E. 6646. Economic Analysis of Chemical Engineering Processes

3-0-3. Prerequisite: graduate standing.

Analysis of chemical engineering problems from the economic standpoint. Economic balance as a controlling factor in equipment design and operation.

Ch.E. 6648-9. Chemical Plant Design

1-6-3 each. Prerequisite: Ch.E. 4434 or consent of school.

Selected methods of chemical plant design.

Ch.E. 6750. Polymer Structure and Physical Properties I

3-0-3. Prerequisite: consent of school.

Morphology and structure, linear and non-linear viscoelasticity, anisotropic mechanical properties and yield and fracture behavior of polymers with applications to textile fibers and plastic products. Also taught as Text. 6750.

Text: at the level of Ward,

Mechanical Properties of Solid Polymers.

Ch.E. 6751. Polymer Structure and Physical Properties II

3-0-3. Prerequisite: consent of school.

Structure-property relationships of elastomers, reinforced plastics, fibers, foams and natural polymers with emphasis on proteins and the composite nature of all polymers and polymer products. Also taught as Text. 6751.

Text: at the level of Ward, *Mechanical Properties of Solid Polymers*.

Ch.E. 6753. Surface Science and Technology Laboratory

3-18-9. Prerequisite: consent of school.

A highly specialized laboratory course using modern analytical and research instrumentation to characterize and study the surface properties of materials. Also taught as Chem. 6753 and Phys. 6753.

Ch.E. 7000. Master's Thesis

Ch.E. 7716. Advanced Unit Operations

3-0-3. Prerequisite: Ch.E. 4413.

Fundamental principles underlying diffusional processes. Development of basic relationships from kinetic theory of gases. Application to diffusional processes including eddy diffusion.

Ch.E. 7736. Chemically Reacting Flow Processes I

3-0-3. Prerequisite: Ch.E. 6603, 6617, 6622.

The development of a generalized approach to chemically reacting flow processes. Chemical vapor deposition and catalysis will be considered.

don and Phillips, *Structure and Properties of Alloys*.

Met. 4423. Metallurgical Fabrication

3-0-3. Prerequisite: Met. 3301 or equivalent.

Primary forming techniques and secondary fabrication and joining processes. Some of the processes to be discussed are casting, rolling, forging, extrusion, drawing, machining and welding.

Met. 4441. Theoretical Physical Metallurgy

3-0-3. Prerequisite: Met. 3301 and Chem. 3413 or equivalent.

A study of the physical and mechanical properties of metals and alloys in the light of their structure.

Text: at the level of Cottrell, *An Introduction to Metallurgy*.

Met. 4445. Electron Microscopy

2-3-3. Prerequisite: Math. 2308 and Met. 3301.

Theory and principles of electron optics and electron microscopy. Preparation and observation of materials by electron microscopy.

Text: At the level of Thomas, *Transmission Electron Microscopy of Metals*.

Met. 4446. X-ray Metallography

3-3-4. Prerequisite: Met. 3301.

Theory and application of x-ray diffraction to metallurgy. Crystal studies, texture studies, phase diagram determination and chemical analysis.

Text: at the level of Cullity, *Elements of X-ray Diffraction* and Azaroff and Donahue, *Laboratory Experiments in X-ray Crystallography*.

Met. 4463. Metallurgical Testing

2-3-3. Prerequisite: Met. 3301.

Destructive and nondestructive test methods are outlined. The emphasis will be on the significance of results and the choice of materials based on test data.

Met. 4464. Nondestructive Testing

2-3-3.

Principles and theory of industrial nondestructive testing methods. Emphasis on testing the soundness and reliability of primary and secondary fabricated metal structures.

Text: at the level of *Nondestructive Testing Handbook*.

Met. 4491. Corrosion and Protective Measures

3-0-3. Prerequisite: Chem. 3413 and Met. 3325 or 4401.

The electrochemical theory of corrosion, recommended materials and protective measures for chemical processing equipment and for atmospheric, underground, underwater and elevated temperature exposures.

Met. 6005. Dental-Medical Materials

2-0-2. Prerequisite: Met. 3301 and Met. 4491.

Theoretical requirements and compatibility of metals as medical implants and a review of up-to-date research. Special lectures will be given by visiting researchers.

Met. 6014. Electrometallurgy

2-3-3. Prerequisite: Chem. 3413 or equivalent.

Electrolytic dissolution and deposition of metals, electrolytic purification, electroplating, anodizing and electropolishing.

Met. 6021. Metallurgical Design Problems

1-6-3. Prerequisite: full graduate standing.

Selection of process equipment design of special equipment, plant layouts and preparation of equipment, utilities. Production costs. Design methods are discussed, evaluated and utilized.

Met. 6025. Powder Metallurgy

1-3-2. Prerequisite: Met. 4423.

Physical and chemical production of metallic powders. Pressing, slipcasting, sintering and the theoretical aspects of these processes. Hot pressing and coining. Industrial applications and materials.

Text: at the level of *ASM Powder Metallurgy*, selected literature by Steinburg, Kuczynski and Schwarzkopf.

Met. 6033. High Temperature Metallurgy

2-0-2. Prerequisite: Met. 4402, 4491.

Property changes with temperature. Creep phenomena. Elevated temperature corrosion. Influence of alloying elements and structure on high temperature properties. Superalloys and cermets. High Temperature testing.

Text: at the level of G. V. Smith, *Properties of Metal at Elevated Temperatures*.

Met. 6035. Advanced Nuclear Materials

3-0-3. Prerequisite: Met. 4403 or equivalent.

Phase diagrams, properties and fabrication of nuclear materials, ceramics, graphite and alloys used for construction, fuel elements, screening and control rods. Welding, corrosion and survey in nuclear engineering.

Met. 6091. Advanced Theory of Metallic Corrosion.

3-3-4. Prerequisite: Met. 4491.

The subject matter covers the latest theories and concepts of metallic corrosion.

Met. 7000. Master's Thesis

Met. 7041. Advanced Physical Metallurgy I

3-0-3. Prerequisite: Met. 4441.

Lattices, melting points, Young's modulus, alloy formation, heat content, conductivity and electrical properties of metals and alloys. Electron energy band and other theories are applied.

Text: at the level of W. Hume-Rothery, *Atomic Theory for Students of Metallurgy*.

Met. 7045. Advanced Electron Microscopy I

3-0-3. Prerequisite: Met. 7051.

This course will emphasize the dynamical theory of image contrast in thin crystalline foils and its application to the interpretation of lattice defects.

Met. 7046. Advanced Electron Microscopy II

3-0-3. Prerequisite: Met. 4445, 7045.

This course will emphasize the application of theories of electron diffraction and image contrast in thin foils to the types of problems commonly encountered in metallurgy.

Met. 7051. Advanced Mechanical Metallurgy

3-0-3. Prerequisite: Met. 4463.

Application of theoretical mechanics to metallurgy. Elastic theory. Crystal plasticity and plastic deformation based on dislocation theory. Rolling and recrystallization textures from theoretical considerations.

Text: at the level of Cottrell, *Dislocation and Plastic Flow in Crystals*.

Met. 7052. Advanced Dislocations and Strengthening Mechanisms I
3-0-3. Prerequisite: Met. 7051.

The emphasis in this course will be on dislocation networks and their effect on the mechanical behavior of materials.

Text: at the level of Friedel, *Dislocations*.

Met. 7053. Advanced Dislocations and Strengthening Mechanisms II
3-0-3. Prerequisite: Met. 7052.

The emphasis in this course will be on the interaction of dislocations with other defects and the correlation of these interactions with the mechanical properties of materials.

Text: at the level of Friedel, *Dislocations*.

Met. 7062. Magnetism in Metals
3-0-3. Prerequisite: Phys. 6231, Met. 4441, 7081.

Magnetism in materials. Electron theory, statistical and thermodynamic interpretation of ferro-, antiferro- and helimagnetism. Ferromagnetism in metals and alloys. Domain theory of hysteresis behavior. Anisotropy and magnetostriction. Magnetic measurements.

Met. 7068. Neutron Diffraction
3-0-3. Prerequisite: Phys. 6231, Met. 4441, 4446.

Neutron scattering properties. Neutron diffraction techniques. Analysis of alloy and magnetic structure. Simple structural systems. Reciprocal space and Fourier transform methods. Inelastic scattering by phonons and magnons.

Text: at the level of Bacon, *Neutron Diffraction*, second edition.

Met. 7081. Metallurgical Thermodynamics

3-0-3. Prerequisite: Met. 7041.

Principles of reversible metallurgical processes. Phase equilibria. Phase transformations in metals and alloys. Theoretical concepts of diffusion, grain boundary energy and melting phenomena.

Text: at the level of Darken and Gurry, *Physical Chemistry of Metals*.

Met. 7085. Metallurgical Kinetics
3-0-3. Prerequisite: Met. 7081.

Reaction kinetics and rate processes applied to physical metallurgy reactions. Theoretical heat transfer in metals. An introduction to theoretical nuclear radiation reaction in metals.

Met. 8001-2-3. Seminar
2-0-1 each. Prerequisite: graduate standing.

The latest advances in metallurgical research and development will be presented by the enrolled students from articles in recent issues of recognized periodicals.

Met. 8100. Special Topics in Advanced Physical Metallurgy

3-0-3. Prerequisite: consent of school.

Representative subjects include alloy theory, phase transformations, magnetic and electric phenomena in metals and special topics in diffraction analysis.

Met. 8500. Special Problems (Master's)

Credit to be arranged.

Lectures, laboratory and library work on special topics of current interest in metallurgy suitable for a master's candidate.

Chemistry

Note: all students are required to wear safety glasses while working in the laboratories. The glasses will be provided at the student's expense.

Chem. 1101-2. General Chemistry 4-3-5 each.

Fundamental laws and theories of chemistry for students who do not plan to take advanced chemistry courses.

Text: at the level of Masterson, Slowinski, *Chemical Principles*, third edition.

Chem. 1111-2. General Chemistry 4-3-5 each.

For students planning to pursue advanced courses in chemistry. In depth studies of chemical principles and the techniques of quantitative analysis necessary for further studies in chemistry.

Text: at the level of Mahan, *University Chemistry*, second edition.

Chem. 2113. Chemical Principles 3-3-4. Prerequisite: Chem. 1112 or Chem. 1102.

Continuation of Chem. 1112 stressing thermodynamics and kinetics and their applications to chemistry. Quantitative experimentation.

Text: at the level of Mahan, *University Chemistry*, second edition.

Chem. 3111-2. Advanced Inorganic Chemistry

4-0-4. each. Prerequisite: Chem. 3411.

A study of the reactions and structures of inorganic compounds and the principles, generalizations and theories which assist in understanding their behavior.

Text: at the level of Heslop, *Inorganic Chemistry*.

Chem. 3311-2-3. Organic Chemistry

3-0-3 each. Prerequisite: Chem. 2113 or consent of department.

Principal classes of organic compounds, aliphatic and aromatic.

Text: at the level of Morrison and Boyd, *Organic Chemistry*, third edition.

Chem. 3381-2-3. Organic Chemistry Laboratory

0-6-2 each. Concurrent with or following Chem. 3311-2-3, respectively; Chem. 3381 prerequisite to Chem. 3382-3.

Studies of reactions, preparation and the techniques used in the organic laboratory.

Chem. 3384. Organic Chemistry Laboratory

0-6-2. Prerequisite: Chem. 3383.

Advanced study of organic reactions, preparations, instrumentations and techniques.

Chem. 3411-2-3. Physical Chemistry

3-0-3 each. Prerequisite: Chem. 2113, Phys. 2122 and Math. 2308.

Physico-chemical properties of matter in the gaseous, liquid and solid states; solutions, equilibrium, kinetics and thermodynamics of chemical reactions, electrochemistry, quantum mechanics.

Text: at the level of Daniels and Alberty, *Physical Chemistry*.

Chem. 3481. Physical Chemistry Laboratory

0-6-2. Concurrent with or following Chem. 3413.

Applications of physical chemistry principles.

Chem. 3491. Physical Chemistry Laboratory

0-6-2. Prerequisite: Chem. 3481. Concurrent with or following Chem. 4401 or consent of department.

Applications of vibration, rotation and electronic spectroscopy, electric and magnetic susceptibility and resonance techniques to the study of molecular structure.

Chem. 3511. Biochemistry

3-0-3. Prerequisite: Chem. 3312.

Introductory course in biochemistry dealing with the chemistry and biochemistry of proteins, lipids, carbohydrates, nucleic acids and other biomolecules.

Text: at the level of Lehninger, *A Short Course in Biochemistry*.

Chem. 3541. Biophysical Chemistry

3-0-3. Prerequisite: Chem. 2113.

Studies of physical concepts (thermodynamics, chemical equilibria, electrolytes, redox reactions, kinetics and physical properties of macromolecules) as related to biological systems.

Chem. 4181. Synthetic Inorganic Chemistry

0-6-2. Concurrently with or following Chem. 3111.

Preparation and characterization of inorganic compounds, with special emphasis on the apparatus and techniques employed in modern synthetic inorganic chemistry.

Text: at the level of Jolly, *Synthetic Inorganic Chemistry*.

Chem. 4211. Instrumental Analysis I

3-6-5. Concurrent with or following Chem. 3411.

Introduction to both theory and

practice of modern instrumental methods: polarography, spectroscopy, colorimetry, microscopy, polarimetry, electroanalytical methods.

Text: at the level of Flaschka, Barnard and Sturrock, *Quantitative Analytical Chemistry*, volume one.

Chem. 4212. Instrumental Analysis II

3-6-5. Prerequisite: Chem. 4211 or consent of department.

Continuation of Instrumental Analysis I.

Text: at the level of Willard, Merrit and Dean, *Instrumental Methods of Analysis*.

Chem. 4231. Advanced Analytical Laboratory

1-6-3. Prerequisite: Chem. 4211 or consent of department.

Advanced analytical techniques and investigations of newer analytical methods in the practice of analysis.

Chem. 4281. Analytical Laboratory

0-6-2. Prerequisite: Chem. 4212.

Advanced techniques and investigations of newer analytical methods in the practices of analysis.

Chem. 4311-2. Organic Reactions

3-0-3 each. Prerequisite: Chem. 3313.

A study of the scope and usefulness of some important reactions and theories in organic chemistry from the standpoint of physical organic chemistry.

Chem. 4341. Applied Spectroscopy

3-0-3. Prerequisite: Chem. 3313.

Application of various spectroscopic techniques in organic analysis.

Text: at the level of Dyer,

Applications of Absorption Spectroscopy of Organic Compounds.

Chem. 4401. Physical Chemistry
3-0-3. Prerequisite: Chem. 2113, Phys. 2123 and Math. 2308 or consent of department.

Application of molecular spectroscopy, electron diffraction, x-ray diffraction, neutron diffraction and magnetic methods to the determination of molecular structure.

Chem. 4452. Chemistry of the Solid State
3-0-3. Prerequisite: Chem. 3413 or consent of department.

Applications of the concepts developed in Chemistry 4741 to the structure of solids and their chemical and physical properties.

Text: At the level of Barrow, *Physical Chemistry*.

Chem. 4511-2-3. Biochemistry
3-0-3 each. Prerequisite: Chem. 3511 or consent of department.

Lectures, independent reading and discussion of topics relating to the chemistry and metabolism of plant and animal products.

Text: at the level of Lehninger, *Biochemistry*.

Chem. 4581. Biochemistry Laboratory
0-6-2. Prerequisite: concurrent with or following Chem. 4511.

Laboratory techniques and practices in biochemistry.

Chem. 4701. Chemistry of Nuclear Technology
3-3-4. For students in nuclear engineering only.

Principles of inorganic, radiation and radio chemistries, separation methods for actinide elements and fission products and topics related

to production and utilization of nuclear energy.

Chem. 4741. Physical Chemistry for Engineers
3-0-3. Prerequisite: M.E. 3720 or equivalent.

Familiarizes students having some thermodynamics in other areas with applications of thermodynamics to chemical systems and with a foundation of the modern theory of chemical bonding.

Text: at the level of Barrow, *Physical Chemistry*.

Chem. 4901-2-3. Special Problems

Credit to be arranged. Prerequisite: departmental approval.

Individualized instruction which will include library, conference and laboratory work.

Chem. 5201. Analysis of Atmospheric Contaminants

3-0-3. Prerequisite: Chem. 1102 or 1112, Math. 1309 and Phys. 2123. May not be used by a student for credit towards any graduate degree in chemistry.

Acquaints the student with modern analytical techniques and instrumental methods of analysis including applications involving the measurement of air contaminants.

Text: at the level of Willard, Merritt and Dean, *Instrumental Methods of Analysis* and Jacobs, *The Chemical Analysis of Air Pollutants*.

Chem. 6111-2-3. Advanced Inorganic Chemistry
3-0-3 each. Prerequisite: Chem. 4112 or consent of department.

The chemistry of inorganic coordination compounds, non-aqueous solvents, the chemistry of uranium and other selected topics.

Text: at the level of Cotton, Wilkerson, *Advanced Inorganic Chemistry*, second edition.

Chem. 6141. Chemical Applications of Group Theory

3-0-3. Prerequisite: Chem. 4112 or consent of department.

An introduction to basic definitions and theorems of group theory and their application to molecular symmetry and quantum mechanics and use in valence bond, molecular orbital and ligand field treatments.

Text: at the level of Cotton, *Chemical Applications of Group Theory*.

Chem. 6151: Chemical Crystallography

3-0-3. Prerequisite: consent of department.

Application of x-ray diffraction to the determination of crystal structures including crystal symmetry, reciprocal lattice, intensity of diffraction, the phase problem and refinement of structure parameters.

Chem. 6211-2. Analytical Chemistry

3-0-3 each. Prerequisite: consent of department.

Theoretical principles and usefulnesses of modern instrumental methods: spectroscopy, microscopy, colorimetry, polarography, polarimetry and electroanalytical methods.

Text: At the level of Flaschka, *et al.*, *Quantitative Analytical Chemistry*, volume one and Willard, *et al.*, *Instrumental Methods of Analysis*.

Chem. 6221. Organic Reagents in Analytical Chemistry

3-0-3. Prerequisite: Chem. 4112.

Chelating agents used in the detection and determination of in-

organic ions, spot testing methods and extraction procedures employing organic reagents.

Chem. 6230. Electrochemistry

3-0-3. Prerequisite: consent of department.

A study of electrochemical instrumentation, the thermodynamics, structure, adsorption of the electrical double layer and the kinetics of simple and complex electrode processes.

Chem. 6231. Electroanalytical Chemistry

3-0-3. Prerequisite: Chem. 4212 or consent of department.

Coulometry, electrolytic separations, polarography, chronopotentiometry, coulometric titrations and voltametric methods of equivalence point detection.

Text: at the level of Lingane, *Electroanalytical Chemistry*.

Chem. 6241. Advanced Analytical Chemistry

3-0-3. Prerequisite: Chem. 3413.

Competing equilibria, including polybasic acids, differential precipitation, complex ion formation in competition with these. Complexometric titrations and homogenous precipitation. Adsorption, partition, ion exchange and gas chromatography.

Chem. 6311-2. Organic Chemistry

3-0-3 each. Prerequisites: Chem. 3313 and consent of department.

Both aliphatic and aromatic compounds.

A more advanced study of the fundamental reactions and theories of structure of various classes of organic compounds.

Text: at the level of House, *Modern Synthetic Reactions*, second edition.

Chem. 6321. Reactivity, Mechanism and Structure in Organic Chemistry

3-0-3. Prerequisite: consent of department.

A general survey of reaction mechanisms and stereochemistry as a guide in design of synthetic sequences.

Text: at the level of Breslow, *Organic Reaction Mechanisms*, second edition.

Chem. 6322-3. Reactivity, Mechanism and Structure in Organic Chemistry

3-0-3 each. Prerequisite: consent of department.

Theoretical interpretations of reactivity, reaction mechanisms and molecular structures of organic compounds.

Chem. 6341. Organic Chemistry

3-0-3. Prerequisite: Chem. 3313 and consent of department.
Significant principles of stereochemistry and conformation analysis, spectroscopy and similar topics which are applicable to an understanding of synthetic organic chemistry.

Chem. 6342. Instrumental Methods of Organic Analysis

3-0-3. Prerequisite: Chem. 4331 or consent of department.

Interpretation of spectroscopic and other common methods of organic analysis and structure determinations.

Chem. 6351. Organometallic Chemistry

3-0-3. Prerequisite: consent of department.

Survey of organometallic chemistry of main group elements, particularly lithium, sodium, beryllium, magnesium, zinc, cadmium, mercury, boron and

aluminum, emphasizing structure, bonding, reaction mechanisms and applications.

Text: at the level of G. E. Coates and K. Wade, *Organometallic Compounds*, volume one. *The Main Group Elements*.

Chem. 6361. Organic Chemistry

3-0-3. Prerequisite: Chem. 3313.

Stereochemistry. Theory and applications of optical and geometrical isomerism and conformational analysis.

Text: at the level of Eliel, *Stereochemistry of Carbon Compounds*.

Chem. 6411-2. Molecular Structure and Chemical Principles

3-0-3 each. Prerequisite: consent of department.

A discussion of molecular structure based upon quantum mechanical principles and its significance in the physical and chemical properties of matter.

Chem. 6421-2-3. Chemical Thermodynamics

3-0-3 each. Prerequisite: Chem. 3413.

Laws of thermodynamics and their chemical applications.

Chem. 6451. Surface Equilibria

3-0-3. Prerequisite: consent of department.

Classical and statistical thermodynamics of surface systems, intermolecular forces at the gas-solid interface, adsorption phenomena and capillarity.

Chem. 6610. Nuclear Chemistry

4-0-4. Prerequisite: Chem. 3413 and Math. 2308.

Properties and structure of the atomic nucleus, radioactivity and decay schemes, interaction of radiation with matter, detection

and experimental methods, nuclear reactors, radiochemical techniques.

Text: at the level of Evans, *The Atomic Nucleus*.

Chem. 6612. Nuclear Chemistry

3-0-3. Prerequisite: Chem. 6610.

A continuation of Chem. 6610.

Chem. 6621. Fast-neutron Interactions

3-0-3. Prerequisite: Chem. 6612 or consent of department.

Properties of the neutron. Forces between nucleons. Fast neutron sources. Experimental methods of detection, spectrometry and calibration of neutrons and neutron sources.

Chem. 6622. Nuclear Fission

3-0-3. Prerequisite: Chem. 6612 or consent of department.

Theory, probability, mass and charge distributions, fragmentations, low, intermediate and high energy processes and photofission processes occurring in nuclear fissions.

Chem. 6631. Radiochemistry

3-0-3. Prerequisite: Chem. 3413.

Properties of atomic nuclei, types of radioactive decay, interaction of radiation with matter and instruments for detection and measurement of radiation.

Text: at the level of Friedlander and Kennedy, *Nuclear and Radiochemistry*.

Chem. 6632. Experimental Radiochemistry

1-3-2. Prerequisite: Chem. 6631.

Radiochemical practice, applications of radioisotopes to methods of analysis, physical chemical studies and reaction mechanisms.

Text: at the level of Overman

and Clark, *Radioisotope Technique*.

Chem. 6753. Surface Science Laboratory

3-18-9. Prerequisite: consent of department.

A highly specialized laboratory course using modern analytical and research instrumentation to characterize and study the surface properties of materials.

Chem. 7000. Master's Thesis

Chem. 7121. Ligand Field Theory

3-0-3. Prerequisite: Chem. 6141.

Introduction to theory of electronic structure of transition metal compounds and its application to the interpretation of physical and chemical properties of these compounds — especially spectral and magnetic properties.

Text: at the level of Royer, *Ligand Field Theory, An Introduction*.

Chem. 7131. Inorganic Stereochemistry

3-0-3. Prerequisite: Chem. 4112 or consent of department.

A discussion of the structure of inorganic compounds and relationships between structures, bonding and properties of these compounds.

Chem. 7141. Mechanisms of Inorganic Reactions

3-0-3. Prerequisite: Chem. 4112 or consent of department.

Discussion of mechanisms of inorganic reactions based on kinetic and stereochemical studies — the substitution and redox reactions of coordination complexes in solution.

Text: at the level of Basolo and Pearson, *Mechanisms of Inorganic Reactions*.

Chem. 7311-2-3. Organic Chemistry

3-0-3 each. Prerequisite: consent of department.

Syntheses and properties of hydrocarbons, alcohols, ethers, halogen, carbonyl, sulfur and nitrogen compounds including carbohydrates, steroids, terpenes and other natural products.

Chem. 7341. Structure Elucidation of Natural Products

3-0-3. Prerequisite: Chem. 6341 or consent of department.

The structure elucidations and detailed chemical syntheses of naturally occurring, physiologically active compounds are studied.

Chem. 7342. Natural Products Synthesis

3-0-3. Prerequisite: Chem. 6312 or consent of department.

Recent advances in the synthesis of naturally occurring compounds such as mono-, sesqui-, di- and triterpenes, steroids, alkaloids and certain animal and plant hormones will be discussed.

Chem. 7351-2. Organic Chemistry

3-0-3 each. Prerequisite: Chem. 6312.

A discussion of the organic chemistry of heterocyclic compounds.

Chem. 7361. Organic Photochemistry

3-0-3. Prerequisite: Chem. 6323 or consent of department.

A survey of the fundamental theoretical and synthetic aspects of photophysical and photochemical concepts of organic chemistry, including energy transfer and primary photochemical processes.

Text: at the level of Lamola and Turro, *Energy Transfer and*

Organic Photochemistry, volume fourteen. *Technique of Organic Chemistry*.

Chem. 7411-2-3. Molecular Spectra

3-0-3 each. Prerequisite: consent of department.

Outline of experimental methods and discussion of atomic energy states, spectra and structure of diatomic and polyatomic molecules, electronic spectra and dissociation phenomena emphasized.

Chem. 7421. Statistical Thermodynamics

3-0-3. Prerequisite: Chem. 6422.

Introduction to the methods of statistical mechanics based primarily on Boltzman statistics, the statistical concept of entropy, approach to thermodynamics through the partition function.

Chem 7431-2. Principles of Quantum Mechanics

3-0-3 each. Prerequisite: Chem. 6411.

A brief review of classical mechanics and the development of wave mechanics and its application to the hydrogen atom. Perturbation theory and other approximate methods.

Chem. 7451. Chemical Kinetics

3-0-3. Prerequisite: Chem. 6421.

Rate and mechanism of chemical reactions including kinetic theory of reactions, activation energy, influence of added electrolytes and influence of solvent.

Chem. 7461-2. Polymer Chemistry

3-0-3 each. Prerequisite: Chem. 6422.

The physical chemistry of addition and condensation polymeriza-

tion processes. The relationship between physical properties and molecular structure. Recent advances will be stressed.

Text: at the level of Flory, *Principles of Polymer Chemistry*.

Chem. 7611. Nuclear Spectroscopy

2-0-2. Prerequisite: Chem. 6612 or consent of department.

A study of nuclear levels and of energy absorption and emission by nuclei both by radioactive decay and by nuclear reaction and scattering experiments.

Text: at the level of Siegbahn, *Alpha-, Beta- and Gamma-Spectroscopy*, volumes one and two.

Chem. 8001-2-3. Seminar
1-0-0 each.

Discussion group composed of staff and graduate students.

Chem. 8111-2. Special Topics in Inorganic Chemistry

3-0-3 each. Prerequisite: Chem. 4112.

Topics to be discussed vary from year to year, will include mechanisms of inorganic reactions, ligand field theory and bonding in inorganic compounds.

Chem. 8211. Special Topics in Analytical Chemistry

3-0-3. Prerequisites: Chem. 3413 and consent of department.

Discussions of specialized areas of analysis: spectrophotometry, polarography, coulometry, chromatography and others. Content of course varies from year to year.

Chem. 8311-2. Special Topics in Organic Chemistry

3-0-3 each. Prerequisite: consent of department.

Topics vary from year to year, will include such subjects as evaluation of synthetic methods and their application to research in organic chemistry.

Chem. 8411-2. Special Topics in Physical Chemistry

3-0-3 each. Prerequisite: Chem. 3413.

Topics vary from year to year, will include such subjects as photochemistry, solid state, surface chemistry and radiation chemistry.

Chem. 8461. Special Topics in Nuclear Chemistry

3-0-3. Prerequisite: Chem. 6612 or consent of department.

Topics vary from year to year, will include nuclear fission, radiochemical techniques, nuclear reactions, in-beam nuclear spectroscopy and on-line investigations of nuclei far from stability.

Chem. 9000. Doctoral Thesis

Civil Engineering

Civil Engineering

C.E. 1503. Introduction to Civil Engineering

2-3-3.

What engineering is, what civil engineering is and what civil engineers do. The civil engineering approach to the solution of mankind's problems.

C.E. 2254. Plane Surveying

3-3-4. Prerequisite: E.Gr. 1170.

Use of modern instruments and office procedures in obtaining and analyzing field data for use in engineering planning, design and construction and in land surveying.

C.E. 2502. Civil Engineering Applications of Digital Computers
1-3-2. Prerequisite: Math. 1308.

A study of the application of digital computers to the solution of civil engineering problems. This course is a prerequisite to all junior and senior C.E. courses.

C.E. 2753. Elementary Surveying
2-3-3. For non-C.E. students.

Use of tape, transit and level with applications to planimetric and topographic mapping, traverse and area computations, stadia, construction surveys.

C.E. 3053. Fluid Mechanics I
3-0-3. Prerequisite: E.S.M. 3201.

Elementary mechanics of fluids with emphasis on analysis, fluid kinematics, equations of motion, momentum and energy principles, surface and form resistance.

C.E. 3054. Fluid Mechanics II
3-3-4. Prerequisite: C.E. 3053.

Elementary mechanics of fluids with emphasis on engineering applications. Enclosed conduit flow, open-channel flow, hydraulic machinery, fluid measurements, dynamic similitude.

C.E. 3061. Fluid Mechanics Laboratory
0-3-1. Prerequisite: C.E. 3054.

Experiment, demonstration and analysis of basic fluid phenomena and exercises in laboratory techniques.

C.E. 3216. Structural Analysis I
5-3-6. Prerequisite: E.S.M. 3301.

Determination of internal forces in statically determinate and indeterminate structures including influence lines with applications to beams, frames and trusses.

C.E. 3254. Advanced Surveying I
3-3-4. Fall and spring quarters. Prerequisite: C.E. 2254.

Field astronomy. Precise taping, leveling, triangulation, sub-tense bar, adjustments of level nets and triangulation figures, special problems in land division, introduction to photogrammetry.

C.E. 3309. Materials of Construction

3-3-4. Prerequisite: E.S.M. 3301, Geol. 2500.

Basic principles of the properties of materials. Physical, chemical and mechanical properties of metals, concrete, timber, masonry and asphalt. The laboratory period is for tests, demonstrations and writing reports.

C.E. 3704. Structural Analysis
3-3-4. Prerequisite: E.S.M. 3702. No credit for C.E. students.

Analysis of structures to find reactions, deflections and internal forces with emphasis on methods of analysis for statically indeterminate structures.

C.E. 4003. Construction

2-3-3. Prerequisite: C.E. 4154, I.Sy.E. 4725.

The relations of construction to design and ultimate use, the construction contract, basic machinery and construction operations, job planning, estimating, cost accounting, preparation of bids.

C.E. 4053. Applied Hydraulics
3-0-3. Prerequisite: C.E. 3054, 4353.

Analysis and design of hydraulic works and structures. Typical exercises: stability of dams, spillway design, stilling basins, culverts, pipe systems, sediment transport, erosion and erosion control.

C.E. 4103. Sanitary Engineering I
3-0-3. Prerequisite: junior standing.

Introduction to water treatment. Evaluation of water quality, public water supplies. Engineering theory and application of disinfection, chemical precipitation, coagulation, adsorption, sedimentation and filtration.

C.E. 4113. Sanitary Engineering II
3-0-3. Prerequisite: C.E. 4103, 4353.

Introduction to waste treatment. Analysis of waste assimilative capacity of a stream. Engineering theory and application of sedimentation, chemical processes, bio-kinetics, fermentation techniques.

C.E. 4123. Sanitary Engineering III
2-3-3. Prerequisite: C.E. 4113.

The layout, hydraulic process and operational design of water and waste water systems. Supervised design problems and inspection trips.

C.E. 4133. Engineering Aspects of Environmental Health

3-0-3. Prerequisite: C.E. 4113.

Sanitary engineering in public health administration and control of environmental health problems.

C.E. 4143. Man in His Environment
3-0-3.

Open to students from all fields. On population, resources, wastes and health as related to development of science and technology.

C.E. 4154. Physical Behavior of Soil and Rock

3-3-4. Prerequisite: C.E. 3309, Geol. 2500.

An introduction to the engineering properties of soil and rock. The origin, composition and structure of soils. The effect of water and its control.

C.E. 4163. Soil and Rock Engineering.

2-3-3. Prerequisite: C.E. 4154.

Mechanics of soil and rock masses as applied to civil engineering design and construction, footing and pile foundations, retaining walls, bulkheads, fills, embankments, control of landslides.

C.E. 4204. Metal Structural Components

3-3-4. Prerequisite: C.E. 3309, 3216.

Principles of behavior of tension and compression members, beams and connections with application to the design of elementary structures.

C.E. 4213. Structural Analysis II

2-3-3. Prerequisite: C.E. 2502, 3216.

Continuation of C.E. 3216 with an introduction to computer applications.

C.E. 4214. Concrete Structural Components

3-3-4. Prerequisite: C.E. 3309, 3216.

Principles of behavior of reinforced concrete beams, columns and slabs with application to the design of elementary structures.

C.E. 4223. Structural Design

2-3-3. Prerequisite: C.E. 4204, 4214, 4154.

Design of structures in metal and concrete with emphasis on buildings and bridges.

C.E. 4233. Design in Timber and Prestressed Concrete

2-3-3. Corequisite: C.E. 4214.

Principles of behavior of timber and of prestressed concrete structural members, application to the design of elementary structures.

C.E. 4253. Elementary Aerial Photogrammetry

2-3-3. Prerequisite: C.E. 3254.

Principles of stereoscopy and stereoscopic instruments. Analytical solutions of altitude, base line, line of flight and parallax. Radial line plotting for planimetric and topographic maps.

C.E. 4263. Engineering Astronomy

2-3-3. Prerequisite: Math. 2308. Spring quarter.

Study of the celestial sphere including horizon and equator systems. Study of the sun, moon, earth and planets, including man's early theories of the universe.

C.E. 4273. Advanced Surveying II

2-3-3. Prerequisite: C.E. 3254. Winter quarter.

Errors and adjustments of surveying and photogrammetric instruments, analysis of measurement errors, Mercator and Lambert projections, plane table traversing, special control problems, hydrographic surveying.

C.E. 4283. Advanced Route Surveying

2-3-3. Prerequisite: C.E. 2254.

Horizontal and vertical curves in transportation systems, application of transition curves, earthwork computations, problems involving fixed points and relocations.

C.E. 4304. Transportation Engineering I

3-3-4. Prerequisite: C.E. 3309.

Planning, design and construction of streets and highways. Computer-oriented laboratory problem acquaints student with modern highway design techniques and criteria.

C.E. 4313. Transportation Engineering II

3-0-3. Prerequisite: senior standing.

History and economics of transportation systems, traffic and planning problems and techniques, planning and design of air, rail, highway and water transportation facilities as a system.

C.E. 4353. Hydrology

3-0-3. Prerequisite: C.E. 3054.

Occurrence and movement of water on the earth, hydrologic measurements, elementary meteorology, precipitation, evapotranspiration and runoff, ground water, frequency analysis.

C.E. 4363. Applied Hydrology

3-0-3. Prerequisite: C.E. 3054, 4353. Winter quarter.

Applications of hydrology in the design of hydraulic structures for water supply, irrigation, power, drainage and flood control facilities.

C.E. 4373. Water Resources Development

2-2-3. Prerequisite: C.E. 4353. Spring quarter.

Comprehensive planning for water resources management, identification of needs, problems and issues, alternative creative solutions, economic and financial evaluation, institutional setting and public participation.

C.E. 4383. Groundwater Hydrology

3-0-3. Prerequisite: C.E. 4353, Geol. 2500. Spring quarter.

Occurrence, distribution and movement of water below the surface of the earth, groundwater resources and dependable supply rates from wells, artificial recharge and waste disposal.

C.E. 4703. Reinforced Concrete Design I

3-0-3. Prerequisite: E.S.M. 3702, Arch. 3323. No credit for C.E. students.

Principles of behavior of reinforced concrete beams and columns with application to the design of elementary structures.

C.E. 4713. Reinforced Concrete Design II

2-3-3. Prerequisite: C.E. 3704, 4703. No credit for C.E. students.

Analysis and design of reinforced concrete foundations, slabs and building frames.

C.E. 4774. Application of Microbiology in Sanitary Engineering

3-3-4. Prerequisite: senior standing. Fall quarter.

Microbiology in environmental engineering. Relationship of protozoa, algae, bacteria and viruses to waterborne disease, treatment of wastes and deterioration of aquatic habitats.

C.E. 4900. Special Problems

Credit hours to be arranged.

C.E. 6003. Construction Administration

2-3-3. Fall quarter.

Management tools used to carry out a modern construction project. Such areas as safety, cost control, equipment usage, incentive plans, labor relations, material purchase and delivery.

C.E. 6013. Civil Engineering Management I

2-3-3. Corequisite: I.Sy.E. 6734. Winter quarter.

Scientific methods in the management of construction projects. Techniques such as C.P.M. and P.E.R.T. for planning, scheduling and control of construction projects.

C.E. 6023. Civil Engineering Management II

2-3-3. Prerequisite: C.E. 6013, I.Sy.E. 6734. Spring quarter.

Continuation of C.E. 6013. Additional applications of scientific methods for management of construction projects. Bidding strategy, allocation of resources using linear programming and value engineering.

C.E. 6053. Steady Flow in Open Channels I

3-0-3. Prerequisite: C.E. 3054, 3061. Fall quarter.

Flow of liquids with free surfaces in natural and artificial channels, general and specific solutions of backwater curve problem, routing of floods through rivers and reservoirs.

C.E. 6058. Intermediate Fluid Mechanics

3-0-3. Prerequisite: C.E. 3054. Fall quarter.

Fundamental treatment in which basic principles of hydro-mechanics are adapted systematically to limitations imposed by properties of real fluids.

C.E. 6063. Steady Flow in Open Channels II

3-0-3. Prerequisite: C.E. 3054, 3061. Winter quarter.

Flow of liquids in channel transitions, bends and obstructions, constrictions and controls, hydraulic jump, stilling basins, hydraulic analysis and design of low weirs, free overfalls, control gates.

C.E. 6068. Advanced Topics in Hydromechanics

3-0-3. Prerequisite: C.E. 6058. Winter quarter.

Potential-flow analysis. Navier-Stokes equations. Turbulent flow.

Laminar and turbulent boundary layers, boundary-layer controls. Diffusion and momentum transfer, cavitation, air-entrainment.

C.E. 6073. Transient Flow in Enclosed Conduits

3-0-3. Prerequisite: C.E. 3054. Spring quarter.

Unsteady flow of compressible and incompressible fluids in conduits, pressure wave propagation, frequency-dependent friction, one-dimensional wave equations, method of characteristics, pulsating flow, water hammer.

C.E. 6078. Engineering Hydrodynamics

3-0-3. Prerequisite: C.E. 6058, Math. 4321. Spring quarter.

Irrrotational flow, principles of continuity, energy and momentum stream and potential functions, introductory conformal transformations, analogies and numerical methods, design applications.

C.E. 6083. Sedimentation and Sediment Transport

3-0-3. Prerequisite: C.E. 3054. Spring quarter.

Sediment entrainment, transportation by suspension, bed load movement. Sediment properties, measurement, sampling techniques and analysis, scour and scour protection at engineering structures, reservoir silting, desilting devices.

C.E. 6088. Gravity-wave Phenomena

3-0-3. Prerequisite: C.E. 6058, Math. 4582. Spring quarter.

Hydrodynamic equations of water waves, reflection, transmission and refraction, tides and wind-generated waves, wave forces of structures, unsteady flow in canals and rivers.

C.E. 6093. Mechanics of Flow in Porous Media

3-0-3. Winter quarter.

Darcy's law, continuity and Laplace equations, steady and unsteady flow in isotropic and anisotropic media. Problems of flow to wells, drains and ditches.

C.E. 6103. Aquatic Chemistry

3-0-3. Prerequisite: C.E. 6139. Spring quarter.

Chemical behavior of natural aquatic systems: lakes, oceans, rivers estuaries, groundwater, wastewater, treatment systems. Analysis of natural waters using physical chemistry principles.

C.E. 6104. Sanitary Engineering Design I

3-3-4. Prerequisite: C.E. 4103. Winter quarter.

Theory and design of structures for collection, purification, conditioning and distribution of public water supplies.

C.E. 6108. Application of Instrumental Analysis in Sanitary Engineering

2-3-3. Prerequisite: C.E. 6139. Winter quarter.

Theory, design, sensitivity and limitations of environmental sampling instruments. Emphasis on spectrophotometric, electromechanical and gas chromatograph analysis of solid waste, water and wastewater.

C.E. 6113. Industrial Wastes Treatment and Disposal

2-3-3. Prerequisite: C.E. 4113. Spring quarter.

Evaluation of industrial waste problems, character and quantity of wastes produced from various industrial activities, application of engineering principles to treatment and disposal techniques.

C.E. 6114. Sanitary Engineering Design II

3-3-4. Prerequisite: C.E. 4113. Spring quarter.

The theory and design of structures for the collection, treatment and disposal of municipal sewage and industrial wastes, the industrial processes which produce liquid wastes.

C.E. 6118. Solid Waste Technology I

2-3-3. Prerequisite: consent of department. Winter quarter.

An introduction of the fundamentals of solid waste characterization, handling and disposal systems, physical and chemical methods of solid waste analysis.

C.E. 6123. Stream Analysis

3-0-3. Prerequisite: C.E. 3054, 4113. Winter quarter.

Factors affecting deoxygenation and reaeration in streams, evaluation of stream self-purification capacity, design of stream surveys, prediction of the effects of organic loading.

C.E. 6124. Air Pollution Measurements and Control

3-3-4. Prerequisite: consent of department. Fall quarter.

Analysis of air pollution problems of cities and industries, methods of evaluating the problems. Description, design and use of air sampling equipment.

C.E. 6128. Solid Waste Technology II

2-3-3. Prerequisite: C.E. 6118. Spring quarter.

Evaluation of typical solid waste problems, application of fundamental principles to design and management, case studies of operational solid waste systems, new methods, advanced topics.

C.E. 6133. Basic Radiological Health

3-0-3. Prerequisite: consent of department. Fall quarter.

An introduction to radiological health and its influence on the general environment and occupational activities, personnel, survey and laboratory instrumentation.

C.E. 6134. Analytical Methods for Air Pollution Studies

3-3-4. Prerequisite: consent of department. Winter quarter.

The study of the methods used for analyzing atmospheric samples, chemical and spectroscopical analysis, emphasis on organic constituents of air samples.

C.E. 6138. Applied Limnology

2-3-3. Spring quarter.

Consideration and application of limnological principles as they pertain to evaluating the impact wastewater disposal will have on the biological productivity of inland waters.

C.E. 6139. Applications of Chemistry in Sanitary Engineering

3-3-4. Prerequisite: Chem. 1102, C.E. 4113. Fall quarter.

Review of general and organic chemistry, concepts of biochemistry and physical chemistry, chemistry of water and wastewater processes. Corrosion, coagulation, softening and disinfection.

C.E. 6144. Sanitary Engineering Processes I

3-3-4. Prerequisite: C.E. 3054, 4113. Winter quarter.

Study of physical processes common to many water and waste treatment systems. Continuous flow models, flocculation, mixing,

sedimentation, cake and filter medium filtration, gas and heat transfer.

C.E. 6145. Field Methods in Sanitary Engineering

0-15-5. Prerequisite: C.E. 6123, 6138. Summer quarter.

Provides experience in the organization and conduct of sanitary surveys and field studies in stream analysis and applied limnology.

C.E. 6148. Advanced Microbiology of Water and Wastes

2-3-3. Prerequisite: C.E. 4774. Winter quarter.

Microbial growth in water and waste treatment systems, enrichment cultures and their application in process design. Respiratory mechanisms and fermentations in waste treatment and stream pollution.

C.E. 6149. Sanitary Engineering Processes II

3-3-4. Prerequisite: C.E. 6144. Spring quarter.

Study of biological and chemical processes employed in water and waste treatment system. Biological growth kinetics, activated sludge, trickling filters, lagoons and oxidation ponds.

C.E. 6153. Dock, Harbor and Shore Structures

3-0-3. Prerequisite: C.E. 4214. Spring quarter.

Function, design and construction of marine structures such as docks, bulkheads, dry docks, breakwaters, channels and shore protection works.

C.E. 6154. Advanced Soil Mechanics

3-3-4. Prerequisite: C.E. 4163. Winter quarter.

Flow of water through soil and

rock, design of drainage systems, earth dams and dam foundations. Elastic and plastic equilibrium applied to problems of slope stability.

C.E. 6159. Rock Mechanics

3-3-4. Prerequisite: C.E. 4163. Spring quarter.

Mechanics of rock masses and influence of geologic features on their engineering properties. Discussion of relevant tests for determination of both in site and laboratory properties of rocks.

C.E. 6163. Physical and Physiochemical Properties of Soils

3-0-3. Prerequisite: C.E. 4154. Fall quarter.

Formation of soils, physical chemistry of soil minerals and soil water, consolidation, swell, shrinkage, shear strength and related phenomena, geology of soil deposits.

C.E. 6164. Advanced Foundation Engineering

3-3-4. Prerequisite: C.E. 4163. Spring and summer quarters.

Analysis and design of foundations, bearing capacity and settlement theory. Analysis of pile and continuous foundations, theories of earth pressure, design of earth-retaining structures.

C.E. 6172. Soil Testing

1-3-2. Prerequisite: C.E. 6194. Winter quarter.

Theory of physical testing of soils for engineering design and research, laboratory exercises in consolidation and shear testing, illustrations of test procedure effects on character of data.

C.E. 6173. Terrain Evaluation and Applications

2-3-3. Prerequisite: C.E. 4163. Fall quarter.

Structure of soil and rock formations and their reflection in the terrain. Analysis of terrain features by aerial photographs and other forms of remote sensing.

C.E. 6174. Dynamic Characteristics of Soils

3-3-4. Prerequisite: C.E. 6163, 6164. Spring quarter.

Determination of basic dynamic properties of soils subjected to vibratory, impact, transient or other dynamic loading, moduli of elasticity, wave propagation, damping and resonance phenomena.

C.E. 6183. Soil Construction

2-3-3. Corequisite: C.E. 4154. Fall quarter.

The migration of soil moisture, frost action, compaction, soil stabilization, evaluation of subgrades and bases for pavements.

C.E. 6193. Dynamics of Massive Media

2-3-3. Prerequisite: C.E. 6174. Summer quarter.

Introduction to dynamics of massive media with applications to analysis of complex engineering dynamics problems. Dynamic properties of soil and rock.

C.E. 6194. Theoretical and Applied Soil Mechanics I

4-0-4. Prerequisite: C.E. 6163. Winter quarter.

Theories of elastic equilibrium of soil masses, application to analysis of complex soil engineering problems such as stresses and settlements of soil and pavement.

C.E. 6199. Theoretical and Applied Soil Mechanics II

4-0-4. Prerequisite: C.E. 6194. Spring quarter.

Theories of plastic equilibrium of soil masses, application to

analysis of complex soil engineering problems. Pressures on earth retaining structures, anchored bulkheads, laterally-loaded piles.

C.E. 6203. Structural Planning

3-0-3. Prerequisite: C.E. 3216. Spring and summer quarters.

Introduction to planning aspects of structural design, economic proportions, erection procedures, comparison of determinate and indeterminate structures, stress control, normal and hybrid behavior.

C.E. 6204. Reinforced Concrete Structures I

4-0-4. Prerequisite: C.E. 4214. Fall quarter.

Review of working stress methods, analysis and design procedures based on ultimate load capacity, effects of creep, shrinkage and temperature, torsional stresses and reinforcing, deflections.

C.E. 6209. Reinforced Concrete Structures II

4-0-4. Prerequisite: C.E. 6204. Winter quarter.

Principles and practices of prestressed concrete, systems and techniques for applying prestress, analysis and design of determinate and indeterminate prestressed concrete structures, ultimate strength behavior.

C.E. 6213. Experimental Analysis I

3-0-3. Winter quarter.

Data acquisition from models. Stress analysis through strain measurements. Transducers, their circuitry and related indicating and recording equipment. Motion measurement, equivalent circuits.

C.E. 6214. Indeterminate Structural Theory I

4-0-4. Prerequisite: C.E. 3216. Fall quarter.

Study of principles and fundamental theorems of structural analysis with applications to indeterminate structures, beams, frames and trusses.

C.E. 6233. Indeterminate Structural Theory II

3-0-3. Prerequisite: C.E. 6214. Winter quarter.

Matrix formulation of behavior of member structures, physical and geometrical non-linearities, force and displacement analysis.

C.E. 6234. Advanced Structural Mechanics

4-0-4. Prerequisite: Math. 2309. Winter quarter.

Study of advanced topics from mechanics of materials with application to civil engineering structures. Typical topics: generalized stress and strain, failure theories, torsion, shear flow, buckling, fatigue.

C.E. 6244. Plastic Design in Steel

4-0-4. Prerequisite: C.E. 4204. Spring quarter.

Analysis and design procedures based on ultimate load capacity are applied to steel beams, frames and their connections.

C.E. 6248. Structural Dynamics

3-0-3. Prerequisite: Consent of department. Fall quarter.

Analysis and design of structures subject to dynamic and static loading, single degree of freedom approach, vibration of structural components, including damping and elasto-plastic behavior.

C.E. 6249. Reinforced Concrete Structures III

4-0-4. Prerequisite: C.E. 6209, Math. 2309. Spring quarter.

Analysis and design of slab and thin-shell structures, additional

applications of prestressing, yield-line theory, shells of revolution, cylindrical shells, folded plates, hyperbolic paraboloids, prestressed tanks.

C.E. 6253. Advanced Aerial Photogrammetry

2-3-3. Prerequisite: C.E. 4253. Winter quarter.

Tilt determinations. Space resection and intersection. Principal point computations for extension of horizontal control. Special problems.

C.E. 6263. Geodetic Engineering

2-3-3. Prerequisite: C.E. 3254. Winter quarter, alternate years.

Geodesy, theory and practice of precise control for surveys of large extent, instrumentation and specifications. Theory of errors, adjustment of observations by approximation, least squares.

C.E. 6273. Legal Principles of Land Surveying

2-3-3. Prerequisite: C.E. 3254. Winter quarter, alternate years.

History and development of legal principles controlling boundary location of real property. Writing, interpreting and locating of deed descriptions.

C.E. 6303. Pavement Design

3-0-3. Prerequisite: C.E. 4304, 4154. Winter quarter.

Theory of flexible and rigid pavement behavior, stress conditions and deflection, climate, pavement design methods and evaluation of pavement performance.

C.E. 6308. Concrete Technology

2-3-3. Prerequisite: C.E. 3309, 4214. Winter quarter.

Design theories for concrete mixes, mixes for specific con-

ditions of workability, density, strength, admixtures and air entrainment. Preparation and testing of concrete mixtures, minor research in concrete.

C.E. 6313. Airport Planning and Design

2-3-3. Prerequisite: C.E. 4304. Fall quarter.

Airport site selection, runway length and orientation, traffic control, drainage and lighting, long-range planning, government responsibility for air transportation.

C.E. 6318. Asphalt Technology

2-3-3. Prerequisite: C.E. 4313, 4154. Spring quarter.

Theory of asphaltic mix design. Preparation of asphaltic mixes for stability, durability, economy. Use of various materials and grades of asphalt in bituminous concrete pavements.

C.E. 6323. Transportation Administration

2-3-3. Fall quarter.

Advanced study of national transportation policies, financial problems, administrative procedures relating to development of transportation facilities.

C.E. 6328. Mass Transit Planning

3-0-3. Prerequisite: consent of department. Winter quarter.

Characteristics and costs of present and innovative mass transit systems. Roles of engineer, planner and others in estimating transit usage and choosing optimal plan.

C.E. 6333. Traffic Engineering

2-3-3. Prerequisite: C.E. 4304. Fall quarter.

Characteristics of drivers and vehicles, traffic studies, capacity, signal systems, engineering solu-

tion of traffic movement problems. Supervised traffic engineering studies.

C.E. 6338. Advanced Traffic Operations

2-3-3. Prerequisite: C.E. 6333. Winter quarter.

Application of traffic control devices to improve capacity, safety of urban street systems. Emphasis on computer control of signal systems, application of computer simulation models.

C.E. 6343. Design of Highways and Transit Facilities

2-3-3. Prerequisite: C.E. 6333. Spring quarter.

Geometric configurations of streets, expressways, busways, railways and their terminals to meet characteristics of vehicle performance and operator limitations.

C.E. 6344. Urban Transportation Planning

3-3-4. Prerequisite: C.E. 6343. Spring quarter.

Planning of urban transportation facilities, mathematical models for prediction of traffic flow, assignment, interrelationship of land use and trips, parking and the transportation problem.

C.E. 6348. Theory of Traffic Flow

2-3-3. Prerequisite: I.Sy.E. 6739, C.E. 6343. Summer quarter.

Traffic flow phenomena, description of traffic arrival, merging movements, shock waves by mathematical models, simulation of traffic flow processes and applications.

C.E. 6353. Economic and Financial Aspects of Public Works Planning

3-0-3. Fall quarter.

Discounting techniques for

public works planning. Micro-economics in project formulation. Applications from welfare economics, capital formation theory, input-output analysis.

C.E. 6358. Issues in Water Resources Planning and Management

3-0-3. Fall quarter.

Major public policy issues in water resource planning and management. Emphasis on American issues, but appropriate reference to issues in other countries.

C.E. 6363. Economics of Water Resources Development

2-2-3. Prerequisite: C.E. 6353. Winter quarter.

Principles of resource allocation, benefit-cost analysis, water-resources project formulation, justification, allocation of joint costs in multipurpose developments.

C.E. 6368. Applied Environmental Resources Management

1-4-3. Spring quarter.

Field, laboratory and classroom studies applied to the solution of an environmental management problem under the direction of a multidisciplinary faculty team.

C.E. 6373. Flood Management

3-0-3.

Hydrology and hydraulics of flood-management measures. Analysis of flood control and flood-damage abatement: levees, floodways, channel improvements, reservoirs.

C.E. 6378. Watershed Analysis

3-0-3. Prerequisite: C.E. 4353. Fall quarter.

Physical hydrology, watersheds as research tools, variable source

area concepts, geomorphology and hydraulic geometry, field trips to research and experimental watersheds.

C.E. 6383. Hydrologic Models

3-0-3. Prerequisite: C.E. 4353. Winter quarter.

Techniques for the statistical analysis of hydrologic data, construction of statistical models of hydrologic processes. Methods of frequency analysis, linear and non-linear least squares.

C.E. 6388. Hydrologic Simulation

3-0-3. Prerequisite: C.E. 6378. Winter quarter.

Digital computer simulation of the land phase of the hydrologic cycle, processes and their interaction, optimization and sensitivity, calibration of a model to measured data, use of the model in a simulation experiment.

C.E. 6393. Urban Hydrology

2-3-3. Prerequisite: C.E. 4353. Spring quarter.

Effects of urbanization on storm runoff, sedimentation, water quality and water supply. Modeling of urban runoff. Urban watershed in planning and design.

C.E. 6398. Hydrology of Floods

2-3-3. Prerequisite: C.E. 6383. Spring quarter.

Flood hydrograph analysis. Rainfall runoff in extreme storms. Synthesis of design flood hydrographs. Evaluation of risk, flood magnitude. Design flood variation with alternative programs.

C.E. 6399. Water Resources Systems Engineering

3-0-3. Prerequisite: C.E. 6383. Summer quarter.

Systems analysis of water

resources operations, design and planning. Characteristics of water resources systems as they relate to operations-research methodologies.

C.E. 6503. Locational Analysis

3-0-3. Prerequisite: graduate standing. Winter quarter.

Mathematical modeling techniques such as differentiation, heuristic algorithms and linear programming for solving location and districting problems.

C.E. 6703. Urban Sanitary Facilities

2-3-3. Fall quarter. No credit for civil or sanitary engineering students.

Basic information for city planner on engineering aspects of water supply, sewage, storm drainage, waste collection and disposal systems, public health administration and environmental sanitation.

C.E. 6704. Urban Transportation Facilities and Policies

3-3-4. Fall quarter. No credit for civil engineering students.

Interrelated planning of urban transportation facilities. The engineering of vehicular thoroughfares including standards, highway capacity estimates, traffic regulation surveys and parking studies.

C.E. 6751-2. Complex Systems Design

2-4-3 each. Prerequisite: graduate standing.

Permits students from all schools to meet, form an interdisciplinary team and carry out a preliminary design of a significant, complex system.

C.E. 6783. Environmental Radiation Surveillance

3-3-4. Prerequisite: C.E. 6133. Spring quarter.

A study of sources and types of radioactive pollutants in the environment with special emphasis on sampling assay and survey techniques.

C.E. 7000. Master's Thesis

Credit hours to be arranged.

C.E. 7999. Doctoral Examinations Preparations

Credit hours to be arranged.

For students preparing for doctoral qualifying or language examinations or both.

C.E. 8001. Seminar in Sanitary Engineering

0-2-1. Prerequisite: consent of department.

Developments in sanitary engineering science and technology, current research and special topics related to environmental quality assessment and control.

C.E. 8011-21. Seminar in Environmental Resources Problems I and II

0-2-1 each. Fall and winter quarters.

Seminar discussions of current environmental management issues. Guest participants will include advocates of different interest groups.

C.E. 8031. Seminar in Soil and Rock Mechanics

0-2-1. Corequisite: C.E. 6154 and consent of the department. Winter quarter.

Case histories of design and construction problems involving soil and rock mechanics, including excavations, drainage, dams,

retaining structures and slope stability.

C.E. 8041. Seminar in Foundation Engineering

1-0-1. Prerequisite: C.E. 6154. Corequisite: C.E. 6164. Spring quarter.

Case histories of design, construction and performance of foundations. Special topics such as machine foundations, foundations in seismic regions.

C.E. 8051. Seminar in Transportation Engineering

1-0-1. Prerequisite: consent of department. Spring quarter.

Developments in the design and planning of traffic engineering and transportation systems, impact of current literature and technology on the field.

C.E. 8061. Construction Seminar
0-2-1. Corequisite: C.E. 6003.

Engineered construction. Whenever possible, guest speakers from the construction industry. Graduate students will present results of required special research projects and thesis research.

C.E. 8101. Special Course
1 credit hour.

C.E. 8102. Special Course
2 credit hours.

C.E. 8103. Special Course
3 credit hours.

C.E. 8104. Special Course
4 credit hours.

C.E. 8105. Special Course
5 credit hours.

C.E. 8113. Special Course
3 credit hours.

C.E. 8114. Special Course
4 credit hours.

C.E. 8123. Special Course
3 credit hours.

C.E. 8500-1-2. Special Problems
Credit hours to be arranged.

C.E. 8756. Master's Special Research Problem

Credit hours to be arranged.

Six to twelve hours of master's research problem to be scheduled by master's students not writing thesis during two or more successive quarters.

C.E. 8999. Doctoral Thesis Preparation

Credit hours to be arranged.

For student in preliminary stages of formulating doctoral research program but who has not obtained formal approval of thesis topic.

C.E. 9000. Doctoral Thesis

Engineering Graphics

E.Gr. 1170. Introduction to Visual Communication and Engineering Design I
2-3-3.

Theory and application of the design process, assigned design project and report. Elements of projection theory that enhance ability to communicate graphically.

Text: at the level of GMSHL, *Engineering Graphics* and Krick, *An Introduction to Engineering and Engineering Design*.

E.Gr. 1171. Introduction to Visual Communication and Engineering Design II
2-3-3. Prerequisite: E.Gr. 1170.

Considers environmental, human, material and socio-

economic factors. Team project reports. Graphical analysis of empirical equations, calculus, nomography.

Text: at the level of GMSHL, *Engineering Graphics* and Krick, *An Introduction to Engineering and Engineering Design* and Edel, *Introduction to Creative Design*.

E.Gr. 1890. Special Topics in Engineering Graphics

2-3-3. Prerequisite: consent of faculty.

Permits students to pursue common, specialized interests in areas of graphics not included or treated extensively in other offerings.

E.Gr. 2213. Industrial Graphics

1-6-3. Prerequisite: E. Gr. 1170.

Simplified techniques, geometric tolerancing, true-position dimensioning as applied to production drawings. Use of air brush for technical illustration.

E.Gr. 3304. Graphic Statics

0-3-1. Prerequisite: E.S.M. 2201.

Graphical solutions of coplanar force systems, resultants, equilibrium of simple structures, funicular polygon through three points, trusses and friction.

Electrical Engineering

E.E. 1001. Introduction to Electrical Engineering

1-0-1.

An introduction to electrical engineering, both at Georgia Tech and in industry. Lectures, discussion and outside work provide insight to the exciting directions the profession is taking.

E.E. 1010. Computer Programming and Graphics

2-3-3.

Computer Programming using Fortran IV and Fortran V languages. Programming problems on the U-1108 computer. Computer graphics with a line printer and a CALCOMP plotter.

Text: Cress, Dirksen and Graham, *Fortran IV with Watfor and Watfiv*.

E.E. 1011. Electrical Engineering Fundamentals

2-3-3.

Survey of the diverse areas within electrical engineering. Basic engineering concepts developed and applied quantitatively to representative engineering problems.

E.E. 1750. Introduction to Bioengineering

3-0-3.

An introduction to aspects of science and technology pertinent to bioengineering.

E.E. 1900 through 1999. Special Problems

Credit to be arranged. Prerequisite: normally taken by freshmen.

Special engineering problems are assigned according to each student's needs, interests and capabilities.

E.E. 2900 through 2999. Special Problems

Credit to be arranged. Prerequisite: normally taken by sophomores.

Special engineering problems are assigned according to each student's needs, interests and capabilities.

E.E. 3015. Mechanical Plant of Buildings

3-0-3. Prerequisite: either E.E. 3200, 3700 or 3725.

Power distribution. Wiring and the National Electrical Code. Light and sight. Photometry. Sources and luminaires. Lighting design by the lumen method.

Text: McGuinness, Stein, Gay and Fawcett, *Electrical Equipment for Buildings*.

E.E. 3032. Computer Engineering I

3-0-3. Prerequisite: E.E. 1010 or equivalent.

Machine language, machine organization and design concepts of digital computers. Loaders, assemblers, subroutines, recursion and re-entrant programs. Microprogram control. Input, output and storage devices.

Text: Gear, *Computer Organization and Programming*.

E.E. 3033. Computer Engineering II

3-3-4. Prerequisite: E.E. 1010 or equivalent.

Number systems, digital logic, boolean algebra and digital logic devices. Computer elements. Microoperations, sequences for complex instructions. Generation of timing and control signals.

Text: Chu, *Introduction to Computer Organization*.

E.E. 3034. Computer Engineering III

3-0-3. Prerequisite: E.E. 3032 or 3033 or the equivalent of either of these courses.

Evaluations and comparisons of computer systems. Measures of performance. Organization of processors, memories, switches, input-output devices, controllers and communication links to form computer systems.

Text: Bell and Newell, *Computer Structures: Readings and Examples*.

E.E. 3035. Introduction to Digital Systems Design

3-3-4. Prerequisite: E.E. 3250.

The study of digital system components and the design of practical systems using the digital synthesizer and current state of the art integrated circuits.

Text: Peatman, *The Design of Digital Systems*.

E.E. 3036. Computational Methods for Simulation

3-0-3. Prerequisite: Math. 2309 or 3308.

A study of numerical algorithms for solving complex electrical engineering problems using digital computers. Theoretical approaches and practical algorithms are discussed.

Text: Hamming, *Introduction to Applied Numerical Analysis*.

E.E. 3042. Electrical Measurements

3-3-4. Prerequisite: E.E. 3250, 3400.

A study of measurements of electrical quantities using electromechanical and electronic, analog and digital methods, consideration of recording, indication and processing of measurement data.

Text: Cooper, *Electronic Instrumentation and Measurement Techniques*.

E.E. 3200. Elements of Electrical Engineering

3-0-3. Prerequisite: Phys. 2122, Math. 2307.

Circuit elements, network theorems, general voltage and current variable analysis techniques, models of active devices, steady state and transient solutions.

E.E. 3210. Circuits and Systems

3-0-3. Prerequisite: E.E. 3250, Math. 3308.

System analysis in the time and frequency domains. Convolution. Poles and zeros. Fourier series and transform, bilateral and unilateral Laplace transforms and their applications.

Text: Frederich and Carlson, *Linear Systems in Communication and Control*.

E.E. 3220. Circuits and Systems

3-0-3. Prerequisite: E.E. 3210.

Representation of dynamical systems, signal flow and state variable techniques. Properties of closed loop systems. System specifications. Stability analysis.

Text: Melsa and Shultz, *Linear Control Systems* and Frederich and Carlson, *Linear Systems in Communication and Control*.

E.E. 3250. Elements of Electrical Engineering

3-0-3. Prerequisite: E.E. 3200.

Operation and modeling of electronic devices with emphasis on biasing, stability, two-port representation, input, output and transfer impedances, mutual inductance and basic circuit configurations.

E.E. 3260. Engineering Electronics

3-0-3. Prerequisite: E.E. 3250.

Frequency analysis of active electronic devices, equivalent circuit modeling of multistage amplifiers, operational amplifier concepts, feedback amplifiers, oscillators, rectifiers and power supply circuits.

Text: Angelo, *Electronics: BJTs, FETs and Microcircuits*

E.E. 3270. Nonlinear Devices and Circuits

3-0-3. Prerequisite: E.E. 3210, 3260.

Analysis and synthesis of nonlinear devices and circuits. Nonlinear shaping circuits, logic circuits, general analysis techniques applicable to nonlinear systems.

Text: Millman and Taub, *Pulse, Digital and Switching Waveforms*.

E.E. 3300. Electromagnetics

3-0-3. Prerequisite: Math. 3308, Phys. 2122 and E.E. 3250.

A study of the Maxwell equations and the Helmholtz wave equations. Electromagnetic theory of simple media. Electrostatics, magnetostatics and electromagnetostatics.

Text: Paris and Hurd, *Basic Electromagnetic Theory*.

E.E. 3310. Electromagnetics

3-0-3. Prerequisite: E.E. 3300, 3210.

Electromagnetic energy and momentum. Virtual work and forces. Reflection and refraction of plane waves in dissipative media. Traveling waves and standing waves.

Text: Paris and Hurd, *Basic Electromagnetic Theory*.

E.E. 3320. Electromagnetics

3-0-3. Prerequisite: E.E. 3310.

Transmission lines and waveguides. Wire and aperture antennas. Arrays. Quasistatics.

Text: Paris and Hurd, *Basic Electromagnetic Theory*.

E.E. 3330. Electromechanical Systems and Energy Conversion

3-0-3. Prerequisite: E.E. 3310, 3210.

Fundamentals of electromechanical energy conversion, electromechanical devices and systems. Energy state functions, force energy relationships, basic transducers, introduction to a-c and d-c machines.

Text: Matsch, *Electromagnetic and Electromechanical Machines*.

E.E. 3340. Random Signals and Noise

3-0-3. Prerequisite: E.E. 3210.

Study of probability, random variables and random processes for applications in communication systems. Considers modulators, demodulators and multiplexing techniques. Analysis of conventional analog modulation systems.

Text: Carlson, *Communication Systems*.

E.E. 3400. Instrumentation Laboratory

1-3-2. Prerequisite: E.E. 3200.

Introduction to instrumentation equipment and techniques. Basic laboratory techniques and practice. Operation of oscilloscopes and meters. Measurement of parameters of electrical engineering components and devices.

E.E. 3410. Junior Electrical Engineering Laboratory I

0-3-1. Prerequisite: E.E. 3250, 3400.

Experiments in linear circuits and electronics, including circuit theorems, FET's, BJT's, diodes, vacuum triodes and integrated circuits.

Text: *Circuits & Electronics Lab Folio of Experiments*, School of Electrical Engineering.

E.E. 3420. Junior Electrical Engineering Laboratory II

0-3-1. Prerequisite: E.E. 3260, 3410. Corequisite: E.E. 3270.

Experimental investigations of functional electronic circuits with emphasis on non-linear operation. Experiments include logic gates and flip-flops, operational amplifiers, silicon-controlled rectifiers, oscillators and multivibrators.

E.E. 3430. Junior Electrical Engineering Laboratory III

0-3-1. Prerequisite: E.E. 3400. Corequisite: E.E. 3320.

Experiments in electromagnetics.

E.E. 3700. Elements of Electric Circuits and Instruments

3-0-3. Prerequisite: Phys. 2122 and Math. 2307.

For non-electrical engineering students. Elements of electric and electronic circuits principally from a terminal characteristics viewpoint. Applications to instrumentation are stressed.

Text: Smith, *Electronics: Circuits and Devices*.

E.E. 3710. Introduction to Electronic Systems

3-0-3. Prerequisite: E.E. 3700.

For non-electrical engineering students. Fundamental active circuits are reviewed and basic linear and digital building blocks developed. Modular approach to system design is stressed through the use of integrated circuits.

Text: Smith, *Electronics: Circuits and Devices*.

E.E. 3720. Rotating Electrical Machine Applications

3-0-3. Prerequisite: E.E. 3700 or 3250.

Basic motor and generator theory with main emphasis on motor application. The principles of motor selection based upon electrical and mechanical considerations are examined.

Text: Smeaton, *Motor Application and Maintenance Handbook*.

E.E. 3725. Electric Circuits and Fields

2-3-3. Prerequisite: Phys. 2122 and Math. 2309.

For mechanical engineering students. Study of electric circuit

elements and the steady state and transient response of circuits to periodic and step inputs. Lectures, quizzes and computation periods.

Text: Fitzgerald, *Basic Electrical Engineering*.

E.E. 3726. Elementary Electronics
2-3-3. Prerequisite: E.E. 3725.

For mechanical engineering students. An introduction to electronic and semiconductor devices and a study of circuits containing such elements. Both linear and digital systems are considered. Laboratory experiments.

Text: Smith, *Electronics: Circuits and Devices*.

E.E. 3727. Electric Power Conversion
2-3-3. Prerequisite: E.E. 3725.

For mechanical engineering students. A study of energy conversion principles and devices such as motors, generators, transformers and rectifiers. Lecture, computation and laboratory periods.

Text: Smeaton, *Motor Application and Maintenance Handbook*.

E.E. 3740. Electrical Instrumentation Laboratory
0-3-1. Corequisite: E.E. 3700.

For non-electrical engineering students. An introduction to the operation and application of basic electrical instruments. Coordinated descriptive lectures and laboratory exercises.

E.E. 3741. Electronic Systems Laboratory
0-3-1. Corequisite: E.E. 3710.

For non-electrical engineering students. An introduction to the design of simple linear and digital electronic systems with the aid of commercially available integrated circuit modules.

E.E. 3742. Electric Machinery Laboratory
0-3-1. Corequisite: E.E. 3720.

An introduction to the principles and application of rotating electric machines.

E.E. 3900 through 3999. Special Problems

Credit to be arranged. Prerequisite: normally taken by juniors.

Special engineering problems are assigned according to each student's needs, interests and capabilities.

E.E. 4012. Electric Energy Conversion
3-3-4. Prerequisite: E.E. 3330.

Principles of rotating a-c and d-c machines. Analysis techniques and application studies of individual and interconnected devices. Coordinated laboratory exercises.

Text: Fitzgerald, et al., *Electric Machinery*.

E.E. 4015. Principles of Feedback Control
3-3-4. Prerequisite: E.E. 3220.

A study of automatic control systems. Basic control principles, system modeling and analysis techniques. Coordinated laboratory exercises.

Text: Ogata, *Modern Control Engineering*.

E.E. 4017. Pulse Circuits
3-0-3. Prerequisite: E.E. 3270.

Systems analysis/design for processing analog and digital data, generation and synchronization of sweeps, switching considerations of MOSEFET multivibrators, active-element memories, D-A and A-D converters.

Text: Strauss, *Wave Generation and Shaping*.

E.E. 4019. Power System Analysis
3-0-3. Prerequisite: E.E. 3330 or consent of school.

A study of power systems, power system components and techniques of analysis.

Text: Stevenson, *Elements of Power Systems*.

E.E. 4020. Solid-State Electronics
3-3-4. Prerequisite: E.E. 4350.

Study of underlying physics and resultant terminal properties of solid-state devices such as transistors, charge coupled devices and microwave to optical devices.

Text: Hunter, *Introduction to Semiconductor Phenomena and Devices*.

E.E. 4021. Electromagnetic Properties of Solids

3-3-4. Prerequisite: E.E. 4350.

Properties of dielectric and magnetic materials including piezoelectricity, superconductivity, magnetic domain dynamics and ferromagnetic resonance. Applications as transducers, memories, logic elements and microwave devices.

E.E. 4022. Industrial Electronics
3-3-4. Prerequisite: E.E. 3210, 3260.

Components and analysis of continuous and two-position industrial control systems, including polyphase and controlled rectifiers, transducers, photosensitive devices and timing circuits.

E.E. 4023. Integrated Circuits and Systems

3-0-3. Prerequisite: E.E. 3270.

A study of integrated circuit technology available today. The merits and drawbacks to electronic applications offered by circuit configurations available in digital and linear ICs.

Text: Fitchen, *Electronic Integrated Circuits and Systems*.

E.E. 4024. Speech Analysis, Synthesis and Compression

3-0-3. Prerequisite: E.E. 3210 or consent of school.

Modern speech analysis and synthesis techniques as applied to the communication problem of speech synthesis. Classical phonology, vocoders, vocal track analogs, spectral analysis of speech.

Text: Flanagan, *Theory of Speech Analysis, Synthesis and Perception*.

E.E. 4025. Information Theory

3-0-3. Prerequisite: E.E. 4061 or equivalent.

Definitions of information, the measure of information, redundancy, channel, channel capacity and mutual information and Shannon's coding theorems are presented and applied to communication problems.

Text: Abramson, *Information Theory and Coding*.

E.E. 4026. Audio Engineering

3-0-3. Prerequisite: E.E. 3270, 3310.

An introduction to the application of the tools of electrical engineering to the detection, measurement, processing, control and reproduction of audio frequency signals.

Text: Olson, *Modern Sound Reproduction*.

E.E. 4027. Computer Graphic Design

3-0-3. Prerequisite: E.E. 1010 or equivalent and junior standing.

Principles of computer-aided design (CAD), with emphasis on interactive graphics. Engineering applications and introduction to

hardware and programming for interactive computing.

Text: Prince, *Interactive Graphics and Computer-aided Design*.

E.E. 4028. Communication Engineering

3-3-4. Prerequisite: E.E. 3210, 3260.

Circuit design for communication system devices operating below one kilomegahertz. Oscillators, amplifiers, mixers, discriminators, modulators, detectors, primarily for analog system applications.

E.E. 4030. Communication Engineering

3-3-4. Prerequisite: E.E. 3210, 3260.

Theory and practice in the design of radio and television receivers. Also a study of signal propagation, radio frequency interference, frequency allocation and fundamental antennas.

E.E. 4032. Communication Circuits

3-3-4. Prerequisite: E.E. 3220.

A study of two-port communication circuits by means of methods of modern network synthesis.

Text: Kuh and Pederson, *Principles of Circuit Synthesis*.

E.E. 4034. High-frequency Measurements

3-0-3. Prerequisite: E.E. 3320.

High-frequency measurements emphasizing the characteristics of standard laboratory equipment together with the techniques of high-frequency measurements. Includes system design and state-of-the-art measurements.

E.E. 4036. Ultra-high-frequency Techniques

3-3-4. Prerequisite: E.E. 3320.

Introduction to waveguides, cavities, klystrons, magnetrons, traveling wave tubes, impatt diodes and ferrite gyrators and circulators. Associated laboratory emphasizes microwave measurements.

Text: Ishii, *Microwave Engineering*; Hewlett Packard Engineering Staff, *Microwave Theory and Measurements*.

E.E. 4037. Antennas

3-3-4. Prerequisite: E.E. 3320.

Introduction to linear antennas, linear arrays and aperture antennas. Far field pattern calculation and measurement are presented. Students design and construct antennas in associated laboratory.

Text: Kraus, *Antennas*.

E.E. 4039. Electrical Sensors and Transducers

3-0-3. Prerequisite: senior standing or consent of school.

Survey of how electrical sensors function and their system applications. Classical, state-of-the-art and advanced sensors and systems are examined for design purposes.

E.E. 4041. Illumination Engineering

3-0-3. Prerequisite: Phys. 2123, E.E. 3310.

An introduction to interior and exterior lighting design. Basic topics considered are light, sight, color, photometry, illumination, luminaires and sources.

E.E. 4042. Electrical Design

3-3-4. Prerequisite: E.E. 3220 or consent of school.

Team-oriented electrical and electronic system design problems of various types. Topics often specified in advance and often

related to national student engineering competitions.

E.E. 4043. Linear Graph Theory

3-0-3. Prerequisite: E.E. 3210.

Comprehensive and unified study of oriented and non-oriented graphs for use in network topology, analysis and synthesis, signal flow theory and communication networks.

E.E. 4046. Power System Engineering

3-0-3. Prerequisite: E.E. 4019.

Modeling of power system element and components, elements of steady-state operation and power system protection.

E.E. 4061. Communication Systems

3-0-3. Prerequisite: E.E. 3340.

Definitions, basic concepts and applications of analog and digital modulation techniques are considered. Modulators for generating various signals and demodulators for information recovery are studied.

Text: Carlson, *Communication Systems*.

E.E. 4071. Modern Network Analysis

3-3-4. Prerequisite: E.E. 3210.

A survey of modern network analysis techniques. Matrix formalism. Multiport and multiterminal networks. Normal-form analysis of linear and nonlinear networks. Active and passive networks.

Text: Kim and Meadows, *Modern Network Analysis*.

E.E. 4076. Special Purpose Digital Systems Design

3-3-4. Prerequisite: E.E. 3035.

Design using commonly encountered systems structures.

Complex performance with hardware simplicity via read-only memories. Design problems implemented on digital synthesizer in digital systems laboratory.

E.E. 4077. Interfacing Small Computers

3-3-4. Prerequisite: E.E. 3035.

The input-output structure of small computers is studied together with the characteristics of a variety of peripheral devices. Emphasis is placed on design problem work.

E.E. 4078. Digital Signal Processing

3-0-3. Prerequisite: E.E. 3220.

An introductory treatment of the theory and applications of digital signal processing.

E.E. 4079. Introduction to Automation Theory

3-0-3. Prerequisite: normally taken by seniors.

A study of the properties of linear sequential systems in relation to their applications in various digital tasks.

Text: Gill, *Linear Sequential Systems*.

E.E. 4080. Introduction to Sequential Systems

3-0-3. Prerequisite: normally taken by seniors.

A study of procedures for synthesis of synchronous and asynchronous sequential systems.

Text: Wood, *Switching Theory*.

E.E. 4081. Introduction to Bioelectronics

3-0-3. Prerequisite: E.E. 3260 or consent of school.

An introduction to the study of the electrical phenomena of biological systems. The measurement and control of biological systems.

Text: Plonsey, *Bioelectric Phenomena*.

E.E. 4082. Linear System Theory
3-0-3. Prerequisite: E.E. 3220.

Linear system theory with emphasis on transform and state-variable methods. Applications to both continuous and discrete systems.

Text: DeRusso, Roy and Close, *State Variables for Engineers*.

E.E. 4083. Computer Simulation of Systems

3-3-4. Prerequisite: E.E. 3220.

Simulation methods by analog, digital and hybrid computers. Digital simulation languages. State variable approach to system simulation. Simulation of complicated systems. Examples and class problems.

Text: Stephenson, *Computer Simulation for Engineers*.

E.E. 4084. Transistor Circuit Analysis

3-0-3. Prerequisite: E.E. 3260. Corequisite: E.E. 4085.

Analysis and design of linear electronic circuits. Large signal amplifiers, multistage amplifiers, linear integrated circuits, tuned amplifiers with emphasis on design techniques.

E.E. 4085. Electronic Design Laboratory

0-3-1. Corequisite: E.E. 4084.

Practical design problems which emphasize creativity and imagination are posed and their solutions are individually implemented in the laboratory.

E.E. 4090. E.E. Senior Seminar
1-0-1. Prerequisite: normally taken by seniors.

Bridge between an undergraduate electrical engineering

education and a postgraduate career. Talk followed by a question and answer period with various authorities.

E.E. 4095. Electrical Transients in Power Systems

3-0-3. Prerequisite: E.E. 3210 or consent of school.

Analysis of transient conditions in power systems. System parameters. Types of transients. Protective devices and techniques.

Text: Greenwood, *Electrical Transients in Power Systems*.

E.E. 4350. Materials Science

3-0-3. Prerequisite: E.E. 3320, 3260.

A study of the physical, electrical and optical properties of metals, semiconductors, dielectrics and magnetic materials with emphasis on microscopic as well as macroscopic behavior.

Text: Wert, *Physics of Solids*.

E.E. 4410. Senior Electrical Engineering Laboratory I

0-3-1. Prerequisite: E.E. 3330, 3400.

Experimental studies in electromechanics and control.

E.E. 4420. Senior Electrical Engineering Laboratory II

0-3-1. Prerequisite: E.E. 3340, 3400.

Experiments in communications systems and signals. Various modulation systems are operated over an additive Gaussian noise channel, demodulated and performance measures conducted.

E.E. 4430. Project Laboratory

0-3-1. Prerequisite: E.E. 3400, normally taken by seniors.

Individual experimental investigations and projects tailored to student interests. Projects are

selected in consultation with student's faculty adviser.

E.E. 4751. Laser Theory and Applications

3-0-3. Prerequisite: Phys. 2123.

Principles of laser operation. Types of lasers. Survey lectures on the applications of lasers to various fields. Course intended for both E.E. and non-E.E. majors. Also taught as Phys. 3751.

E.E. 4780. Energy Conversion Engineering

3-0-3. Prerequisite: Thermodynamics.

Principles of advanced energy conversion for electric power. Operation and engineering considerations. Also taught as M.E. 4780 and N.E. 4780.

Text: Angrist, *Direct Energy Conversion*.

E.E. 4801-2-3-4-5. Special Topics

3-0-3 each. Prerequisite: normally taken by seniors.

New developments in electrical engineering are presented as demand or interest warrants.

E.E. 4900 through 4999. Special Problems

Credit to be arranged. Prerequisite: normally taken by seniors.

Special engineering problems are assigned according to each student's needs, interests and capabilities.

E.E. 6050. Random Processes

3-0-3. Prerequisite: graduate standing.

An introduction to the concepts of probability theory and random variables with applications to electrical engineering problems.

E.E. 6051. Random Processes

3-0-3. Prerequisite: E.E. 6050, Math. 4221 or equivalent.

An introduction to the theory of stochastic processes. Filtering and harmonic analysis. Energy properties. Wiener, Poisson, Gaussian, Markov processes. Engineering applications are emphasized.

E.E. 6061. Statistical Detection Theory

3-0-3. Prerequisite: E.E. 6050.

Basic binary and m-ary digital signaling techniques are studied, with emphasis on the effects of noise in these systems. Error probabilities are used for system comparisons. Fading radio channels and diversity techniques are discussed.

E.E. 6062. Modulation Theory

3-0-3. Prerequisite: E.E. 6061.

Design of a digital communications system. Coding strategies. Quantization. Decoding algorithms. Effects of non-white noise, unknown attenuation, fading. Continuous wave modulation, linear, twisted, frequency modulation, PCM.

E.E. 6063. Methods in Pattern Recognition

3-0-3. Prerequisite: E.E. 6061.

Introduction to pattern recognition. Several approaches to pattern classification will be presented, including the linear discriminant function approach, perceptrons, Bayesian learning and nearest neighbor rule.

E.E. 6071. Communication Circuits and Signals

3-0-3. Prerequisite: graduate standing or consent of school.

Discussion of Fourier transforms and related topics from moderately advanced viewpoint, emphasis on applications to electrical networks, sampling, antennas, statistics, optics. Transform-domain reasoning and insight stressed.

E.E. 6072. Fourier Optics and Holography

3-0-3. Prerequisite: E.E. 6071 or consent of school.

Principles of diffraction, lenses, coherent and incoherent imaging, optical information processing and holography presented in a linear invariant systems framework.

E.E. 6081. Information Theory

3-0-3. Prerequisite: E.E. 6050.

Introduction to information theory. The concepts of information, information rate and channel capacity are developed and applied to communication theory problems. Rate-distortion theory is introduced.

E.E. 6082. Coding

3-0-3. Prerequisite: E.E. 6050.

Coding techniques for efficient, reliable communication are introduced. Techniques studied include parity-check, maximal-length, hamming, BCH and convolutional codes, sequential decoding and coding for burst-noise channels.

E.E. 6091. Radar Engineering

3-0-3. Prerequisite: E.E. 6131, 6061.

Statistical decision and estimation theory as applied to radar situations. Slowly fluctuating point targets, singly and doubly spread targets, accuracy, ambiguity and resolution. Performance bounds.

E.E. 6092. Computer Communication Systems

3-0-3. Prerequisite: graduate standing.

Provides information necessary for the design or analysis of computer-to-computer data transmission systems.

E.E. 6100. Linear Networks and Systems

3-0-3. Prerequisite: graduate standing.

Introduction to a rigorous treatment of linear systems theory. Topics include theory of vector spaces, linear transformations, state variables, linear dynamical systems, controllability and observability.

E.E. 6101. Time Varying and Nonlinear Systems

3-0-3. Prerequisite: E.E. 6100.

Analysis and design of engineering systems with time varying and/or nonlinear characteristics. Systems representation and properties of the presentation. Linearization techniques. Stability analysis using Liapunov and Popov's theories.

E.E. 6111. Feedback Control Systems

3-0-3. Prerequisite: E.E. 6100.

Optimal control approach to control system design. Formulation of optimal control problems using state-space approach, dynamic programming, calculus of variations and maximum principle.

E.E. 6112. Feedback Control Systems

3-0-3. Prerequisites: E.E. 6101, 6111 or consent of school.

Design techniques for linear, nonlinear automatic control systems. Synthesis of linear systems, closed loop response and performance. Minimum time, fuel and error design.

E.E. 6113. Feedback Control Systems

3-0-3. Prerequisite: E.E. 6100.

Application of discrete time control to continuous systems. Time and frequency domain analysis of sampled data systems.

E.E. 6131. Optimum Linear Filters

3-0-3. Prerequisite: E.E. 6051, 6101 or consent of school.

Linear filtering theory, both classical and modern approaches. Applications in communication and control. Particular emphasis on Wiener-Hopf filter and Kalman filter.

E.E. 6152. Computer Simulation

3-0-3. Prerequisite: graduate standing or consent of school and elementary programming ability.

A study of computational methods for use in the digital simulation of deterministic systems. Several simulation projects are a part of the course.

E.E. 6153. Computer Simulation

3-0-3. Prerequisite: E.E. 6050 or consent of school and elementary programming ability.

Nondeterministic systems — a study of problems associated with generating and analyzing random time series using digital computers. Spectral estimation and statistical inference are among topics covered.

E.E. 6161. Digital Systems Engineering I

3-0-3. Prerequisite: graduate standing.

Functional organization and sequential operations of digital computers. Number representation, digital arithmetic, computer elements, micro-operations and sequences for instruction execution and control and command logic.

E.E. 6162. Digital Systems Engineering II

3-0-3. Prerequisite: graduate standing.

Concepts, technology related to microprogramming. Comparison

of sequential hardware control and microprogrammed control. Design parameters, tradeoffs for control memory, control word structures. Evaluation of several microprogrammable systems. Future impact.

E.E. 6163. Digital Systems Engineering III

3-0-3. Prerequisite: graduate standing.

Assembly language programming. The "MIX" machine simulated on the U-1108. Programming problems in "MIX." Advanced programming techniques. Information structures, dynamic storage allocation.

E.E. 6201. Automata Theory

3-0-3. Prerequisite: graduate standing.

An introduction to broad classes of digital systems including computer components as special cases. A detailed study is made of steps leading to optimum design.

E.E. 6202. Automata Theory

3-0-3. Prerequisite: E.E. 6201.

A continuation of digital system study including fault detection and decomposition of systems. Reliability, memory span and quadded logic are also examined.

E.E. 6203. Automata Theory

3-0-3. Prerequisite: E.E. 6202 or consent of school.

An introduction to finite automata through study of sequential circuits. Concepts in modern algebra are developed for direct application to sequential circuits.

E.E. 6211. Digital Systems Engineering Laboratory

0-3-1. Prerequisite: E.E. 6161 or equivalent.

Digital computer engineering. Registers, transfer level logic

devices, hardwired structures, microprogrammed structures, memory, input-output.

E.E. 6251. Applied Electromagnetics

3-0-3. Prerequisite: graduate standing or consent of school.

Advanced electromagnetic theory. Particular and complementary solutions to the symmetric wave equations for both the discrete and continuous cases. Analysis, synthesis and boundary value problems.

E.E. 6252. Microwaves

3-0-3. Prerequisite: E.E. 6251.

Field analysis of guided waves. Equivalent-circuit theory for microwave systems. Broadband impedance matching. Passive microwave devices. Microwave cavities. Periodic structures and filters.

E.E. 6253. Antennas

3-0-3. Prerequisite: E.E. 6251.

Classical antenna theory. The antenna as a receiver. Uniform and non-uniform arrays. Pattern synthesis. Cylindrical antennas and arrays. Slot antennas, horns and reflector antennas.

E.E. 6301. Electro-optics

3-0-3. Prerequisite: graduate standing.

Introduction to electro-optics with emphasis on lasers and modern optics. Parametric interactions, Kerr and Pockels effect, harmonic generation. Applications include communications, data processing.

E.E. 6351. Advanced Electrical Measurements

3-3-4. Prerequisite: graduate standing.

Theory of measurement and

practical application of instrumentation. Measurement uncertainties, system modeling, component parts of system accuracy, data accumulation, reduction and interpretation are considered.

E.E. 6361. Integrated Circuits

3-0-3. Prerequisite: graduate standing.

Design, fabrication and application considerations of monolithic ICs. Analysis of the unconventional circuitry contained in typical integrated circuits. Applications of available logic lines and linear ICs.

E.E. 6401. Advanced Network Theory

3-3-4. Prerequisite: graduate standing.

Special techniques of network analysis that are not usually covered in undergraduate curricula. Topics include networks involving active elements, multiport or multiterminal elements, pathological elements.

E.E. 6402. Advanced Network Theory

3-3-4. Prerequisite: graduate standing.

A survey of various techniques of passive analog filter design. The objective is to enable the student to design practical filters with understanding of underlying principles.

E.E. 6403. Advanced Network Theory

3-3-4. Prerequisite: graduate standing.

Techniques of synthesizing networks using active elements such as gyrators, controlled sources, immittance transducers, operational amplifiers. Practical filter design using these elements.

E.E. 6411. Distributed-Parameter Networks

3-0-3. Prerequisite: graduate standing.

Analysis and synthesis of distributed-parameter networks. Uniform and nonuniform lossy and lossless transmission lines. Application of these networks in integrated circuits is also considered.

E.E. 6412. Time-domain Synthesis of Linear Networks

3-0-3. Prerequisite: graduate standing.

Methods of specifying a network function to give a prescribed time-domain response. Mathematical techniques suitable for obtaining the time-domain approximating functions.

E.E. 6413. Digital Filters

3-0-3. Prerequisite: graduate standing or consent of school.

Unified theory of digital processing of signal and spectrum analysis. Digital filter design and applicable analog filter review. Discrete Fourier transforms including fast Fourier transform.

E.E. 6421. Advanced Network Theory II

3-0-3. Prerequisite: graduate standing or consent of school.

An introduction to applied combinatorics including combinations, permutations, recursion, partition, generating functions, inclusion and exclusion, rook polynomials and Polyá's theorem.

E.E. 6422. Advanced Network Theory II

3-0-3. Prerequisite: graduate standing.

Topological analysis of networks. Current interest topics presented from a linear-graph

aspect. Concepts and techniques of network and system analysis by topological methods.

E.E. 6423. Advanced Network Theory II

3-0-3. Prerequisite: consent of school.

Specialized topics of current interest in network theory.

E.E. 6451. Electrical Properties of Materials

3-0-3. Prerequisite: graduate standing or consent of school.

Basis of quantum mechanical formalism and modeling to serve as an introduction to the modern study of electrical properties of materials.

E.E. 6452. Magnetic and Dielectric Properties of Materials

3-0-3. Prerequisite: E.E. 6451 or consent of school.

Dielectrics, piezo- and ferroelectrics and their application to electromechanical devices. Quantum basis of magnetism. Magnetic interactions, domains, resonance and devices.

E.E. 6453. Solid-state Electronic Devices

3-0-3. Prerequisite: graduate standing or consent of school.

Study of charge and energy transport in semiconductors with applications in pn junction, interface and thin film, optoelectronic and bulk-effect devices.

E.E. 6461. Modern Magnetic Materials and Devices

3-0-3. Prerequisite: E.E. 6452 or consent of school.

Basic operation and design of magnetic memories and microwave devices. Crystal structure, chemical composition. Properties of ferrites, garnets and orthoferrites.

E.E. 6500. Introduction to Management and Control of Energy Systems

3-0-3. Prerequisite: E.E. 6100 or consent of school.

Fundamentals of static as well as dynamic system theory as applied to typical energy engineering problems. Optimization theory, decision analysis techniques for large-scale systems.

E.E. 6501. Planning of Power Systems

3-0-3. Prerequisite: E.E. 4019, 6050 or consent of school.

An introduction to planning procedures for large scale technical operations. Technical and economic constraints on planning. Techniques for formulation of rational planning problems.

E.E. 6502. Control and Operation of Interconnected Power Systems

3-0-3. Prerequisite: E.E. 4019, 6100 or consent of school.

Operation of interconnected systems. Models for system interaction, techniques for control and management of power flow and reliability.

E.E. 6503. Evaluation of Power System Reliability

3-0-3. Prerequisite: E.E. 4019, 6050 or consent of school.

Techniques for the study of power system reliability. Probabilistic models for power system performance. Techniques for subsystem and composite system reliability analysis.

E.E. 6511. Transmission Lines

3-3-4. Prerequisite: graduate standing.

A study of electric power transmission parameters, models and techniques for analysis of

steady state and transient conditions. A-c, d-c, HV and underground transmission.

E.E. 6521. Power System Stability

3-0-3. Prerequisite: E.E. 4019, 6100.

Static and dynamic stability, generator swing equation. Techniques for stability analysis. Voltage and frequency control.

E.E. 6750. Systems Design Methodology

2-3-3. Prerequisite: graduate standing or consent of school.

An introduction to complex system design, interdisciplinary. Also taught as A.E. 6750, M.E. 6750.

E.E. 6751-2. Complex System Design

2-4-3 each. Prerequisite: graduate standing or consent of school.

The class acts as an interdisciplinary team to carry out a significant relevant preliminary design of a complex system. Also taught as A.E. 6751-2, M.E. 6751-2.

E.E. 6760. Atomic Collisions

3-0-3. Prerequisite: graduate standing in science or engineering.

A discussion of the techniques by which atomic collisions phenomena are studied, includes scattering of ions and electrons in gases and scattering from solid surfaces. Also taught in the School of Physics.

E.E. 6988. Noise in Communications Systems

3-0-3. Prerequisite: E.E. 6062.

Basic binary and m-ary digital signaling techniques are studied, with emphasis on the effects of noise in these systems.

E.E. 6989. Introduction to Plasma Dynamics

3-0-3. Prerequisite: E.E. 6451.

The theoretical study of plasma dynamics. Considers charged particle orbits in electric and magnetic fields, space charge, current sheaths and electromagnetic waves in ionized gases.

E.E. 6990. Plasma Diagnostics

3-3-4. Prerequisite: E.E. 6989.

Diagnostic techniques applicable to determining properties of plasmas. Topics include macroscopic measurements, electric and magnetic probes, optical and microwave techniques. Selected laboratory experiments.

E.E. 6991. Hydromagnetics

3-0-3. Prerequisite: E.E. 6989.

The theoretical study of the motion of conducting fluids in magnetic fields. Natural hydromagnetic phenomena. Engineering applications.

E.E. 7000. Master's Thesis**E.E. 7051-2-3. Advanced Communication Theory**

3-0-3 each. Prerequisite: E.E. 6051, 6062.

Latest developments in communications are treated in lecture and seminar. Emphasis on current literature and open research areas.

E.E. 7101-2-3. Advanced Feedback Control Theory

3-0-3 each. Prerequisite: consent of school.

Advanced techniques for analysis and design of automatic control systems.

E.E. 7251-2-3. Advanced Electromagnetic Theory

3-3-4 each. Prerequisite: E.E. 6251 or consent of school.

Topics of fundamental importance in electromagnetics. Advanced developments in the fields of antennas, propagation, and microwave theory and practice.

E.E. 7999. Preparation for Doctoral Qualifying Exams

Non-credit.

Preliminary doctoral examination. Spring quarter.

E.E. 8001-2-3. Seminar

1-0-1 each.

E.E. 8011-2-3. Seminar

1-0-0 each.

E.E. 8140 through 8149. Special Topics

1-0-1 each.

Special topics of unusual current interest: introductory treatments of new developments in electrical engineering.

E.E. 8240 through 8249. Special Topics

2-0-2 each.

E.E. 8340 through 8349. Special Topics

3-0-3 each.

E.E. 8430 through 8439. Special Topics

4-0-4 each.

E.E. 8440 through 8449. Special Topics

5-0-5 each.

E.E. 8500 through 8998. Special Problems

Credit to be arranged.

Problems meeting the special problems of the student. Approval to schedule must be obtained in advance of registration.

E.E. 9000. Doctoral Thesis

Engineering Science and Mechanics

E.S.M. 1101. Introduction to Engineering 2-3-3.

The engineer and design, relation between the student's curriculum and his career in engineering. Emphasis placed on student participation in creative design process.

Text: at the level of Beakley and Leach, *Engineering: An Introduction to a Creative Profession*.

E.S.M. 1750. Introduction to Bio-Engineering 3-0-3.

Bio-engineering aspects of human body including its mechanics, nervous system control, material properties and biological fluid flows. Diagnostic techniques and assisting and replacement prosthetic devices. Also listed as A.E. 1750, E.E. 1750, M.E. 1750.

E.S.M. 1901 through 1909. Special Problems in Engineering Science 3-0-3, maximum. Prerequisite: freshman standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty advisor.

E.S.M. 2101. Engineering Design I 0-3-1. Prerequisite: E.S.M. 1101 or consent of department

Study of a problem that arises from a need of society. Proposals for a creative solution studied to select best design.

E.S.M. 2102. Engineering Design II

0-6-2. Prerequisite: E.S.M. 2101.

Continuation of E.S.M. 2101.

Design of problem to be completed, a model to be submitted as part of final report.

E.S.M. 2201. Statics

3-0-3. Prerequisite: Phys. 2121. Prerequisite or corequisite: Math. 2307.

Elements of statics in two- and three-dimensions, centroids, analysis of structures and machines, friction.

Text: at the level of Beer and Johnston, *Vector Mechanics for Engineers: Statics*, or Lnenicka, Bernard and Stoneking, *Programmed Statics*.

E.S.M. 2901 through 2909. Special Problems in Engineering Science 3-0-3, maximum. Prerequisite: sophomore standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty advisor.

E.S.M. 3111. Experimental Methods in Engineering Science 2-3-3. Prerequisite: E.E. 3400, Math. 2309, E.S.M. 3201, 3301.

Methods used to observe behavior of physical parameters in engineering problems, photo-optics, signal analysis, transducers and transducer circuits, models and analogies.

Text: at the level of Tuve and Domholdt, *Engineering Instrumentation*.

E.S.M. 3201. Dynamics I

3-0-3. Prerequisite: E.S.M. 2201, Math. 2307.

Kinematics and kinetics of rigid bodies in plane motion.

Text: at the level of Beer and Johnston, *Vector Mechanics for Engineers: Dynamics*.

E.S.M. 3202. Dynamics II

3-0-3. Prerequisite: E.S.M. 3201.

Kinematics and kinetics of three-dimensional motion of rigid bodies.

Text: at the level of Beer and Johnston, *Vector Mechanics for Engineers: Dynamics*.

E.S.M. 3301. Mechanics of Deformable Bodies

5-0-5. Prerequisite or corequisite: E.S.M. 2201, Math. 2308.

Definition and analysis of strain and stress, applications to axially loaded elements, torsion of circular shafts and bending of beams, introduction to simple plasticity and to column stability.

Text: at the level of Popov, *Introduction to the Mechanics of Solids*.

E.S.M. 3302. Mechanics of Materials

3-0-3. Prerequisite: E.S.M. 3301.

Analysis and design of beams (using singularity functions), various structural elements (using energy methods), thick-walled cylinders, rotating disks, curved beams. Theories of failure.

E.S.M. 3451. Computer Applications in Engineering Science and Mechanics

2-3-3. Prerequisite or corequisite: E.S.M. 3302, 4210, 3501 or consent of department.

Introduction to the use of the digital computer, Fortran languages, computer solutions of problems in statics, dynamics, mechanics of deformable solids, vibrations and fluid mechanics.

E.S.M. 3501. Fluid Mechanics

5-0-5. Prerequisite: E.S.M. 3302. Prerequisite or corequisite: Math 2308.

Kinematics of fluid motion, material and spatial coordinates,

acceleration, continuity, vorticity, perfect fluid motion, introduction to the motion of a viscous fluid.

Text: at the level of Owczarek, *Introduction to Fluid Mechanics*.

E.S.M. 3701. Statics

3-0-3. Prerequisite: Arch. 2301, Math. 1309, Phys. 2111.

Elements of coplanar statics, particle and rigid body equilibrium, centroids, centers of gravity, distributed loads, analysis of structures and beams, shear and bending moment.

Text: at the level of Beer and Johnston, *Mechanics for Engineers: Statics*.

E.S.M. 3702. Mechanics of Materials

3-0-3. Prerequisite: E.S.M. 3701.

Simple stresses and strains, mechanical properties of materials, Hooke's Law, moments of inertia of areas, analysis and design of beams and columns, deflection of beams.

Text: at the level of Popov, *Mechanics of Materials*.

E.S.M. 3711. Dynamics

5-0-5. Prerequisite: E.S.M. 2201.

Kinematics of particles and rigid bodies, kinetics of translation, rotation and plane motion, work and energy relations.

Text: at the level of Work, *A Programmed Instruction in Dynamics*.

E.S.M. 3901 through 3909. Special Problems in Engineering Science

Credit to be arranged. Prerequisite: junior standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty adviser.

E.S.M. 4111. Introduction to Experimental Stress Analysis

1-6-3. Prerequisite: E.S.M. 3301 or equivalent, senior standing.

Plane stress analysis using transmitted light photoelasticity and photoelastic models, study of surface strain using resistance strain gages, transducer design and application.

Text: at the level of Holister, *Experimental Stress Analysis*.

E.S.M. 4121. Projects in Engineering Science

3-0-3. Prerequisite: consent of department.

Experimental and/or theoretical investigation of an engineering problem, individual student effort with faculty project advisor, written report.

E.S.M. 4201. Intermediate Dynamics I

3-0-3. Prerequisite: E.S.M. 3202 or consent of department.

Kinematics and kinetics of particles and particle systems, applications include motion in resisting medium, redistribution of mass, central force motion, effects of earth rotation.

Text: at the level of Marris and Stoneking, *Advanced Dynamics*.

E.S.M. 4202. Intermediate Dynamics II

3-0-3. Prerequisite: E.S.M. 4201 or consent of department.

Two- and three-dimensional motion of a rigid body, Euler's equations, introduction to energy methods and Lagrange's equations.

E.S.M. 4210. Mechanical Vibrations I

3-0-3. Prerequisite: E.S.M. 3201, E.S.M. 3301 and Math. 2309 or their equivalent.

Single degree-of-freedom

system, two degrees-of-freedom system and finitely many degrees-of-freedom system complex representation, applications.

Text: at the level of Thomson, *Vibration Theory and Applications*.

E.S.M. 4211. Mechanical Vibrations II

3-0-3. Prerequisite: E.S.M. 4210 and E.S.M. 3302 or equivalent. Fall quarter.

Complex representation, step and impulse loads, many degrees of freedom, influence coefficients, matrix methods, stability of solution, vibrations of strings, beams and membranes, approximate methods.

Text: at the level of Thomson, *Vibration Theory and Applications*.

E.S.M. 4301. Mechanics of Deformable Bodies

3-0-3. Prerequisite: E.S.M. 3301.

Small strain linear elasticity in two- and three-dimensions, applications in generalized plane stress and plane strain, torsion and bending of non-circular prisms.

E.S.M. 4302. Stress Analysis

3-3-4. Prerequisite: E.S.M. 4301.

Continuation of E.S.M. 4301, further treatment of torsion and bending, strain energy, introduction to thin plates and simple shells, approximation methods.

E.S.M. 4351. Continuum Mechanics

3-0-3. Prerequisite: Math. 2309, E.S.M. 3301.

Geometrical foundations, analysis of stress and deformation, balance laws, constitutive equations, finite and infinitesimal elasticity.

E.S.M. 4401. Materials Science

3-0-3. Prerequisite: senior standing.

Introduction to fatigue, creep, effect of shape, size, temperature and microstructure of specimen, more common stress-strain equations, hysteresis, after effect, etc., theories of failure.

Text: at the level of Cottrell, *The Mechanical Properties of Matter*.

E.S.M. 4451. Biomechanics

3-0-3. Prerequisite: Math. 4582 or equivalent, E.S.M. 3501 or equivalent.

Mechanical modeling of human body, muscle mechanics, steady non-Newtonian flows, material properties of human body, hemodynamics, anomalies of blood, wave propagation in arteries.

E.S.M. 4801 through 4809. Special Topics in Engineering Science

1-0-1 through 9-0-9, respectively. Prerequisite: senior standing.

Special courses not included in regular course offerings.

E.S.M. 4901 through 4909. Special Problems in Engineering Science

Credit to be arranged. Prerequisite: senior standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty adviser.

E.S.M. 6111. Theory of Experimental Stress Analysis

2-3-3. Prerequisite: E.S.M. 6341 or consent of department. Spring quarter.

Study of surface stress and strain using brittle coatings and electrical resistance strain gages, strain gage circuits, static and dynamic problems, transducer design and circuits.

E.S.M. 6115. Introductory Photoelasticity

1-6-3. Prerequisite: E.S.M. 6341 or

consent of department. Fall quarter.

Polarized light, mathematical description and light transformations, solution of plane stress problems using transmitted light, separation of principal stresses, photoelastic models.

E.S.M. 6116. Photoelasticity

1-6-3. Prerequisite: E.S.M. 6115. Winter quarter.

Three-dimensional stress analysis using transmitted light and scattered light methods, birefringent coatings, Moire fringes, numerical methods.

E.S.M. 6201. Advanced Dynamics I

3-0-3. Prerequisite: E.S.M. 4210 and Math. 2309, or equivalent. Fall quarter.

Kinematics and kinetics of particles, angular velocity, inertia properties, rigid body dynamics, generalized coordinates and forces, nonholonomic systems, solutions by vector methods and Lagrange's equations.

E.S.M. 6202. Advanced Dynamics II

3-0-3. Prerequisite: E.S.M. 4202 or 6201. Winter quarter.

A continuation of E.S.M. 6201. Hamilton's principle, Hamilton's canonical equations, energy and momentum integrals, Hamilton-Jacobi theory, study of selected papers from recent dynamics literature.

E.S.M. 6221. Theory of Oscillations

3-0-3. Prerequisite: Math. 4582 or consent of department. Fall quarter.

Lagrange's equations, normal modes, orthogonality, dynamic coupling, small oscillations of conservative systems, non-conservative systems, vibrations of flexible strings and elastic bars.

E.S.M. 6222. Vibration of Elastic Bodies

3-0-3. Prerequisite: E.S.M. 6221, 6341. Winter quarter.

Free and forced longitudinal, torsional and lateral vibration of beams, with and without damping, vibration of membranes, plates and shells, waves in isotropic elastic media.

E.S.M. 6241. Gyroscopic Motion and Devices

3-0-3. Prerequisite: E.S.M. 6201 or equivalent. Spring quarter.

Motion of a rigid body about a fixed point, the top, precession and nutation of the earth, the gyrocompass, rate and integrating gyros, the monorail, ship stabilizers.

E.S.M. 6261. Space Mechanics I

3-0-3. Prerequisite: graduate standing. Fall quarter.

The two-body problem, Kepler's equation, transfer orbits, Hohmann transfer, dynamics of rocket motion, rocket staging.

E.S.M. 6262. Space Mechanics II

3-0-3. Prerequisite: E.S.M. 6261 or consent of department. Winter quarter.

Celestial sphere, aberration, parallax, Laplace's and Gauss' methods, three- and n-body problems, Lagrangian points, Lagrange brackets, perturbations of an oblate planet and atmospheric drag.

E.S.M. 6263. Dynamics of Space Vehicles

3-0-3. Prerequisite: E.S.M. 6201, 6231. Spring quarter.

Single-stage and multistage rockets, bending and torsional vibrations, propellant sloshing, basic equations of motion, control system stability, control elements, response of space vehicles to winds.

E.S.M. 6281. Random Vibrations I

3-0-3. Prerequisite: Math. 4215 and E.S.M. 4210, or consent of department. Winter quarter.

Statistical analysis of mechanical systems, correlation function, power spectral density, response to random inputs, method of normal modes, fatigue failures, non-stationary inputs, vibration of beams.

E.S.M. 6282. Random Vibrations II

3-0-3. Prerequisite: E.S.M. 6281. Spring quarter.

Continuation of E.S.M. 6281. Advanced engineering problems in random theory, nonstationary random inputs and response, measurement of power spectra, Fokker-Planck techniques, nonlinear systems.

E.S.M. 6301. Advanced Strength of Materials

3-0-3. Prerequisite: Math. 2309, E.S.M. 3301. Summer quarter.

Shear centers for beams, analyses of stresses and deflections in unsymmetrical bending, stresses and deflections in curved flexural members, beams on elastic supports.

E.S.M. 6321. Applied Elasticity I

3-0-3. Prerequisite: E.S.M. 3301 or equivalent. Fall quarter.

Analysis of stress and strain, stress-strain relations, equilibrium, compatibility and boundary conditions, simple three-dimensional applications, plane elasticity problems in Cartesian and polar coordinates.

E.S.M. 6322. Applied Elasticity II

3-0-3. Prerequisite: E.S.M. 6321. Winter quarter.

Continuation of Applied Elasticity I, torsion and flexure of bars, introduction to thermoelasticity,

finite-element, finite-difference approximations and relaxation method as applied to elasticity problems.

E.S.M. 6341. Theory of Elasticity I
3-0-3. Prerequisite: E.S.M. 3301 and Math. 2309 or consent of department. Fall quarter.

Introduction to generalized tensors, analysis of deformation, equations of motion, linearly elastic materials, formulation of the first, second and mixed boundary value problems.

E.S.M. 6342. Theory of Elasticity II
3-0-3. Prerequisite: E.S.M. 6341 or consent of department. Winter quarter.

Continuation of E.S.M. 6341, linear elasticity, Saint-Venant's theory of torsion, bending of beams, Love's strain function, Galerkin vector, Papkovitch-Neuber representation, stress potentials, Airy's stress function.

E.S.M. 6343. Theory of Elasticity III
3-0-3. Prerequisite: E.S.M. 6342 or consent of department. Spring quarter.

Continuation of E.S.M. 6342, variational formulation of elasticity, energy theorems, introduction to thermoelasticity, representation of biharmonic functions by analytic functions of a complex variable.

E.S.M. 6361. Theory of Elastic Stability I

3-0-3. Prerequisite: E.S.M. 3301, Math. 4582 or consent of department. Winter quarter.

Various stability methods and their applicability, the elastica problem, snap and bifurcation buckling, stability of conservative systems, buckling of beams on elastic foundation, lateral buckling.

E.S.M. 6362. Theory of Elastic Stability II

3-0-3. Prerequisite: E.S.M. 6361 or consent of department. Spring quarter.

Stability of various systems – velocity dependent, conservative, dissipative, circulatory and instantaneous, with examples of each, recent developments in elastic stability theory.

E.S.M. 6371. Theory of Plates

3-0-3. Prerequisite: graduate standing and Math. 4582 or equivalent. Spring quarter.

Von Karman theory of plates, pure bending of laterally loaded rectangular and circular plates, approximate methods, nonlinear considerations, stiffened and layered anisotropic plates.

E.S.M. 6372. Theory of Shells

3-0-3. Prerequisite: E.S.M. 6371 or consent of department. Summer quarter.

Stresses and deformation of shells with and without bending under various loading conditions, shells forming surfaces of revolution, hyperbolic paraboloidal and elliptic paraboloidal shells.

E.S.M. 6381. Plasticity

3-0-3. Prerequisite: E.S.M. 6341 or consent of department. Spring quarter.

Stress-strain relations in three dimensions, three-dimensional yield conditions and flow laws, thick-walled tube and sphere, torsion of bars, slip line fields, technological processes, plates.

E.S.M. 6391. Finite Elasticity

3-0-3. Prerequisite: E.S.M. 4351 or consent of department. Winter quarter.

Kinematics of finite deformation, stress, deformation and strain ten-

sors, classical theory of finite elasticity for isotropic materials, introduction to simple materials.

E.S.M. 6401-2. Optimization Techniques I and II

3-0-3 each. Prerequisite: graduate standing. Winter and spring quarters.

Applications of calculus of variations to optimization of engineering systems and processes, end and corner conditions, discontinuous optimal processes, control and state variable inequality constraints, direct methods, etc.

E.S.M. 6411. Energy Methods in Mechanics

3-0-3. Prerequisite: E.S.M. 3301, Math. 4582 or consent of department. Summer quarter.

Virtual work, minimum total potential energy, minimum complementary energy, Castigliano's theorems, applications of calculus of variations, Rayleigh-Ritz method.

E.S.M. 6501-2. Fluid Mechanics

3-0-3. Prerequisite: graduate standing. Fall and winter quarters.

Mechanical principles of rational fluid mechanics. Kinematics, balance laws, examples of constitutive equations of fluids including perfect, Navier-Stokes, Rivlin-Ericksen fluids, potential flows, viscometric flows, introduction to approximate solutions and boundary-layer theory.

E.S.M. 6751-2. Complex Systems Design

2-4-3 each. Prerequisite: graduate standing of any school or senior with consent of school.

Interdisciplinary team design of systems of current interest to society which have large

technological factors. Individual research and interaction with non-university resource persons and faculty. Grades based on oral and written reports. Cross-listed with A.E., E.E., C.E., C.P., I.Sy.E. and M.E.

E.S.M. 6760-1-2. Acoustics I, II and III

3-0-3 each. Prerequisite: Math. 4349 or consent of department.

Introductory analytical methods, and stochastic process, the wave equation in a compressible fluid, radiation of wind, reflection, refraction, diffraction and scattering of sound waves, duct acoustics. Also listed as A.E. 6760-1-2 and M.E. 6760-1-2.

E.S.M. 7000. Master's Thesis

E.S.M. 7221. Nonlinear Vibrations I

3-0-3. Prerequisite: E.S.M. 4210, 6201 and Math. 4582 or their equivalents. Winter quarter.

Vibrations of autonomous one degree-of-freedom systems, method of approximated characteristics, topological methods, analysis of singularities and stability, free damped nonlinear vibrations, self-excited oscillations.

E.S.M. 7222. Nonlinear Vibrations II

3-0-3. Prerequisite: E.S.M. 7221. Spring quarter.

Nonlinear vibrations of non-autonomous one degree-of-freedom systems, method of Duffing, perturbation method, Bogoliuboff method, Ritz-averaging method, stability criteria, subharmonics, two degree-of-freedom systems.

E.S.M. 7223. Selected Topics in Nonlinear Vibrations

3-0-3. Prerequisite: E.S.M. 7222 or consent of department. Fall quarter.

Extension of the Ritz-averaging method, pulse excitation, parameter excited systems, Ince-Strutt stability plane, methods of approximation, free and forced nonlinear elastic systems.

E.S.M. 7231. Wave Propagation in Continuous Media

3-0-3. Prerequisite: E.S.M. 6501 or consent of department.

The theory of propagation of singular surfaces in three dimensions, Hadamard's lemma, Maxwell's theorem, compatibility conditions for weak singular surfaces, general balance at a singular surface, weak waves, applications to wave propagation in various materials.

E.S.M. 7232. Wave Propagation in Continuous Media – Solids

3-0-3. Prerequisite: E.S.M. 6342. Spring quarter.

Wave propagation in elastic media, dilatational, equivoluminal and surface waves, one-dimensional wave propagation in structural elements, method of characteristics.

E.S.M. 7344. Theory of Elasticity IV

3-0-3. Prerequisite: E.S.M. 6343 or consent of department. Fall quarter.

Topics in elasticity selected according to student interest and background.

E.S.M. 7371. Stability of Shells

3-0-3. Prerequisite: E.S.M. 6361, 6372. Fall quarter.

Linear and nonlinear theories for shell buckling, stability of thin stiffened and unstiffened plates and cylindrical shells under various loads, edge effects, imperfection sensitivity studies.

E.S.M. 7401. Finite Element Methods I

3-3-4. Prerequisite: knowledge of computer programming and consent of instructor.

Review of discrete analysis methods and origin and basis of finite element methods in continuum mechanics. Generalization of finite element concept. Accuracy and convergence. Use of digital computer.

E.S.M. 7402. Finite Element Methods II

3-0-3. Prerequisite: E.S.M. 7401 or consent of instructor.

Hybrid model theory. Applications to plate and shell problems. Composite structures. Fracture mechanics. Nonlinear formulations. Error estimations. Solution techniques and computer applications.

E.S.M. 7501. Viscoelasticity

3-0-3. Prerequisite: E.S.M. 6391, 6501 or consent of department. Spring quarter.

The theory of viscoelasticity, simple fluids, viscometric flows and the determination of material functions.

E.S.M. 7511. Analytical Fracture Mechanics

3-0-3. Prerequisite: E.S.M. 6341 and Math. 4321 or equivalent.

Half-plane problems. Symmetric crack problems. Crack-extension criteria. Antisymmetric crack problems. Williams' series. Effect of nearby boundaries. Crack growth under cyclic loading. Design problems.

E.S.M. 7750. Bio-fluid Mechanics

3-0-3. Prerequisite: A.E. 6000 or E.S.M. 6501, 6502 or consent of instructor.

A unified treatment on hemorheology, hemodynamics,

pulsatile flows, microcirculation, joint lubrication, pulmonary physiology, etc., with emphasis on quantitative approach. Also listed as A.E. 7750.

E.S.M. 7999. Preparation for Doctoral Qualifying Examination
Non-credit. Prerequisite: consent of adviser.

E.S.M. 8000-1-2-3. Graduate Seminar
1-0-1 each.

E.S.M. 8101-2. Special Topics
1-0-1, 2-0-2 respectively. Prerequisite: consent of adviser.

Special ad hoc courses not included in regular E.S.M. graduate course offerings.

E.S.M. 8103-13-23-33-43-53. Special Topics
3-0-3. Prerequisite: consent of adviser.

Special ad hoc course not included in regular E.S.M. graduate course offerings.

E.S.M. 8104-14-24-34-44-54. Special Topics
4-0-4 each. Prerequisite: consent of adviser.

Special ad hoc courses not included in regular E.S.M. graduate course offerings.

E.S.M. 8105-15-25-35-45-55. Special Topics
5-0-5 each. Prerequisite: consent of adviser.

Special ad hoc courses not included in regular E.S.M. graduate course offerings.

E.S.M. 8501-2-3. Special Problems
Credit to be arranged. Prerequisite: consent of adviser.
Individual study and analysis of

problems of current and future interest in engineering and science.

E.S.M. 8999. Doctoral Thesis Preparation
Credit to be arranged.

For student in preliminary stages of formulating doctoral research program but who has not obtained formal approval of thesis topic.

E.S.M. 9000. Doctoral Thesis

English

Engl. 0050. Reading for Speed and Comprehension
2-0-2.

Mechanics of reading. Exercises in increasing speed and improving comprehension. The course is conducted as a laboratory.

Engl. 1001-2-3. Analysis of Literature
3-0-3 each. Freshman year. Courses must be taken in numerical sequence.

Analysis of selected literary works, with special attention to relationship of content and form. Intensive practice in written composition about the literature studied. Discussions, papers.

Engl. 1010. Vocabulary Building
3-0-3.

Development of a useful vocabulary required in technical and scientific courses and general reading. Recitations, written exercises, individual practice and research, quizzes.

Engl. 1031-2-3. English for International Students
5-0-5 each. Freshman year, consecutive quarters. Admission by consent of the department.

Introduction to written and spoken English, stressing pronunciation, idioms and language appropriate to American social situations and customs. English 1033 includes some study of literature.

Engl. 2001-2-3. Survey of the Humanities

3-0-3 each. Prerequisite: Engl. 1001-2-3.

A sequence of courses studying the contribution of several Western civilizations from the Greeks to modern times as revealed in literature. Lectures, reports, papers, quizzes.

Engl. 2004. Survey of English Literature

3-0-3. Prerequisite: Engl. 1001-2-3. May be substituted for Engl. 2003.

A study of English literature since Shakespeare, with emphasis on significant figures and their works through the 19th century. Lectures, reports, papers, quizzes.

Engl. 2007. Survey of American Literature

3-0-3. Prerequisite: Engl. 1001-2-3. May be substituted for Engl. 2003.

A study of the development of literature in America, with emphasis on significant figures and their works through the 19th century. Lectures, reports, papers, quizzes.

Engl. 2010. Creative Writing

3-0-3. Prerequisite: Engl. 1001-2-3.

Study and practice in several forms and methods of creative writing. Recitations, conferences, compositions.

Engl. 2031-2-3. Literature for International Students

5-0-5 each. Sophomore year, consecutive quarters. Prerequisite: Engl. 1031-2-3.

An introduction to American ideas as expressed in American literature, with continued training in writing and speaking American English.

Engl. 2037-8-9. Acting and Producing the Play

0-3-1 each. Prerequisite: consent of the department.

Participation in the DramaTech productions of various kinds of plays, including the presentation of one play before an audience.

Engl. 3006. The English Language

3-0-3. Prerequisite: Engl. 1001-2-3.

Study of the origin of the English language, its relation to other languages and its differentiation and development into modern English and American.

Engl. 3008. Logic and the Use of Language

3-0-3. Prerequisite: Engl. 1001-2-3.

Study of principles of logic and semantics and their use in increasing effectiveness of oral and written communication. Analysis of fallacies in the mass media.

Engl. 3015. Public Speaking

3-0-3. Normally taken by juniors and seniors.

Instruction in the basic principles of effective public speaking, with emphasis on practice and criticism. The course is conducted as a laboratory.

Engl. 3018. Persuasive Speaking

3-0-3. Prerequisite: consent of the department.

Principles of argumentation and persuasion. Practice in their application, with emphasis on issues of current public interest.

Engl. 3019. Oral Communication in Science, Business and Industry

3-0-3. Prerequisite: Engl. 3015.

Study of informative oral communication in science, business and industry. Practice in committee, panel and technical briefing settings. Emphasis on use of audio-visual aids.

Engl. 3023. Written Communication in Science, Business and Industry

3-0-3. Normally taken by juniors and seniors.

Practice in application of principles of effective written communications to important types of professional writing — reports, letters, memoranda. Case method of instruction and individual projects.

Engl. 3024. Advanced Writing

3-0-3. Prerequisite: Engl. 1001-2-3.

Intensive practice in composition at an advanced level in informative, argumentative and persuasive forms. Discussion of principles and theory of composing. Analysis of appropriate models.

Engl. 3037-8-9. Acting and Producing the Play

0-3-1 each. Prerequisite: consent of the department.

See Engl. 2037-8-9.

Engl. 3041. Writers in the Age of Galileo

3-0-3. Prerequisite: Engl. 1001-2-3.

Study of works of three of the following: Donne, Bacon, Jonson, Milton, Defoe. Emphasis on their reflection of social, scientific, philosophical attitudes of the age.

Engl. 3042. Writers in the Age of Newton

3-0-3. Prerequisite: Engl. 1001-2-3.

Study of the works of three of the following: Swift, Fielding, Thoreau, Wordsworth, Keats. Emphasis on their reflection of

social, scientific, philosophical attitudes of the age.

Engl. 3043. Writers in the Age of Darwin

3-0-3. Prerequisite: Engl. 1001-2-3.

Study of works of three of the following: Carlyle, Melville, Arnold, Tennyson, Twain. Emphasis on their reflection of social, scientific, philosophical attitudes of the age.

Engl. 3044. Writers in the Age of Freud and Einstein

3-0-3. Prerequisite: Engl. 1001-2-3.

Study of works of three of the following: James, Yeats, Shaw, Lawrence, Eliot. Emphasis on their reflection of social, scientific, philosophical attitudes of the age.

Engl. 3051. Chaucer I

3-0-3. Prerequisite: Engl. 1001-2-3.

Introduction to the poetry of Chaucer in Middle English. Major emphasis on the study of *The Canterbury Tales*.

Engl. 3052. Shakespeare

3-0-3. Prerequisite: Engl. 1001-2-3.

A brief statement of the life and times of Shakespeare and a careful study of certain of his principal works. Lectures, reports, papers, quizzes.

Engl. 3056. Joyce

3-0-3. Prerequisite: Engl. 1001-2-3.

A study of the works of James Joyce, with particular emphasis on Joycean techniques of fiction as developed in *Ulysses* and other selected works.

Engl. 3058. Contemporary Drama

3-0-3. Prerequisite: Engl. 1001-2-3.

An analytical survey of prominent playwrights and trends in contemporary drama. Lectures, reports, collateral reading, quizzes.

Engl. 3059. Contemporary Fiction

3-0-3. Prerequisite: Engl. 1001-2-3.

An analytical study of prominent writers and trends in contemporary fiction. Lectures, reports, collateral reading, quizzes.

Engl. 3061. The Literature of the Bible: The Old Testament

3-0-3. Prerequisite: Engl. 1001-2-3.

Study of selected Old Testament writings, with emphasis on literary quality and intellectual content. Discussion of both in the cultural heritage of the western world.

Engl. 3062. The Literature of the Bible: The New Testament

3-0-3. Prerequisite: Engl. 1001-2-3.

Study of selected New Testament writings, with emphasis on literary quality and intellectual content. Discussion of both in the cultural heritage of the western world.

Engl. 3076. Faulkner

3-0-3. Prerequisite: Engl. 1001-2-3.

A study of selected works of William Faulkner, with particular emphasis on major themes and the nature of his narrative art.

Engl. 3081-2-3-4-5-6. Seminars in Literature

3-0-3 each. Prerequisite: consent of the department.

Intensive study of individual writers, movements, periods or themes in literature, with the purpose of developing knowledge in depth, critical independence and expository skill.

Engl. 4041. Studies in the Novel

3-0-3. Prerequisite: Engl. 1001-2-3.

Intensive analysis of selected novels, with emphasis on the artistic excellence and significance of the works in the development of modern scientific and philosophical attitudes.

Engl. 4042. Studies in the Drama

3-0-3. Prerequisite: Engl. 1001-2-3.

Intensive analysis of selected plays, with emphasis on the artistic excellence and significance of the works in the development of modern scientific and philosophical attitudes.

Engl. 4043. Studies in Poetry

3-0-3. Prerequisite: Engl. 1001-2-3.

Intensive analysis of selected poems, with emphasis on the artistic excellence and significance of the works in the development of modern scientific and philosophical attitudes.

Engl. 4044. Studies in the Essay

3-0-3. Prerequisite: Engl. 1001-2-3.

Intensive analysis of selected essays, with emphasis on the artistic excellence and significance of the works in the development of modern scientific and philosophical attitudes.

Engl. 4051. Chaucer II

3-0-3. Prerequisite: Engl. 3051.

Continuation of Engl. 3051. Major emphasis on the study of *Troilus and Criseyde*.

Engl. 4081. Seminar in Themes and Problems in Contemporary Literature

3-0-3. Prerequisite: Engl. 1001-2-3.

Intensive study of works of modern literature which treat the theme of man and himself as these works reflect problems of concern to contemporary times.

Engl. 4082. Seminar in Themes and Problems in Contemporary Literature

3-0-3. Prerequisite: Engl. 1001-2-3.

Intensive study of works of modern literature which treat the theme of man and society as these works reflect problems of concern to contemporary times.

Engl. 4083. Seminar in Themes and Problems in Contemporary Literature

3-0-3. Prerequisite: Engl. 1001-2-3.

Intensive study of works of modern literature which treat selected issues of immediate concern to contemporary times.

Engl. 4901-2-3-4. Special Problems

Credit to be arranged. Prerequisite: consent of the department.

Studies in specialized aspects of literature and language selected on basis of current interest.

Geophysical Science

Geol. 1000. Introduction to Earth Science

3-0-3.

A survey of planetary science, atmospheric science and oceanography giving general insight into the nature of man's environment.

Geol. 2100. General Geology

3-0-3.

Earth's structure, composition and the records of geologic time. Origin of rocks, evolution and migration of the continents.

Geol. 2300. Survey of Oceanography

3-0-3.

Selected topics from geological, physical, chemical and biological oceanography, marine technology, marine environment, resources from the sea. Relationships between man and the sea.

Geol. 2500. Physical Geology

3-3-4. Corequisites: Chem. 1102 or 1112 and Phys. 2121.

Introduction to nature of minerals and rocks, processes for-

ming them and their pattern in space and time. Laboratory exercises on minerals, rocks and geologic maps.

Geol. 3000. Earth Resources

3-0-3.

A study of Earth's physical resources — fresh water, land (soils), minerals and fuels — emphasizing the geologic origin, geographic distribution and future availability of the resources.

Geol. 3100. History of the Earth

3-3-4. Prerequisite: Geol. 2100 or 2500.

Antiquity of Earth. Interacting evolution of biosphere, atmosphere and lithosphere on the primitive Earth. Phanerozoic history and life. Evolution of living systems. Rise of man.

Geol. 3400. Mineralogy

3-3-4. Prerequisite: Geol. 2500 or consent of school.

Crystal bonding and symmetry, crystal structure and crystal chemistry, application to geologically important minerals. Laboratory devoted to hand specimen identification, x-ray diffraction, chemical analysis.

Geol. 3410. Optical Mineralogy

1-3-2. Prerequisite: Geol. 3400 or consent of school.

A brief introduction to the use of the polarizing microscope for the identification and study of thin sections of rocks and minerals.

Geol. 3500. The Earth-Moon System

3-0-3. Prerequisite: Phys. 2123.

Physical interactions of earth, moon and sun, structure and evolution of earth and moon as a planetary system, introduction to lunar geology.

Geol. 4100. The Influence of Man's Activities on the Global Environment

3-3-4. Prerequisite: Geol. 2500.

The interacting equilibrium of atmosphere, hydrosphere, biosphere and lithosphere. The interfering effects of man's activities on the cyclic equilibria on the earth.

Geol. 4150. Petrology of the Sedimentary Rocks

2-3-3. Prerequisite: Geol. 3410 or Cer. E. 4120.

Texture, composition and structure of sediments and sedimentary rocks, sedimentary processes (hydraulics and aqueous geochemistry), analysis of sedimentary environments.

Geol. 4200. Structural Geology

3-3-4. Prerequisite: Geol. 2500.

Structures produced by rock deformation during tectonic and metamorphic activity. Primary structural features. The laboratory will include several field trips.

Geol. 4240-1-2. Field Methods in Geology

0-6-2 each. Prerequisite: Geol. 2500.

Methods of description, mapping and analysis of rock units and structures in the field.

Geol. 4250. Engineering Geology

3-3-4. Prerequisite: Geol. 2500.

Applications of geological science to problems of civil engineering.

Geol. 4300. Introduction to Physical and Chemical Oceanography

3-0-3. Prerequisite: Geol. 2500 or consent of school.

Ocean geometry, physical properties of sea water, water movements and energy fluxes,

sediments, marine geochemistry, marine geophysics and tectonics, ocean history.

Geol. 4400. Petrology of Igneous and Metamorphic Rocks

3-3-4. Prerequisite: Geol. 3410, 4200.

Composition, texture and structure of igneous and metamorphic rocks. Physical, chemical and geologic conditions controlling metamorphism and igneous activity. Microscopic laboratory study.

Geol. 4500. Introduction to Geophysics

3-0-3. Prerequisite: Geol. 2100 or 2500.

General survey of terrestrial geophysics. Topics discussed include the earth's seismicity, internal structure, shape, gravity, magnetic field, paleomagnetism, heat flow and global tectonics.

Geol. 4550. Applied Geophysics

3-3-4. Prerequisite: Geol. 2100 or 2500, Phys. 2143.

Theory of electrical, magnetic, gravity, seismic refraction and reflection exploration methods. The laboratory provides exercises in instrumentation and data interpretation.

Geol. 4600. Introduction to Geochemistry

3-3-4. Prerequisite: Geol. 3400.

Distribution and behavior of the chemical elements and natural compounds in the earth, its waters and its atmosphere. Application of chemical principles to geologic processes.

Geol. 4800. Special Topics

0-6-2.

Geol. 6050. Geophysics I - Seismology and Heat Flow

3-3-4. Prerequisite: consent of school.

An intense theoretical survey of terrestrial geophysics. Topics include seismology, wave motion, structure of earth's interior and heat flow. Laboratory stresses directed projects.

Geol. 6051. Geophysics II – Gravity

3-3-4. Prerequisite: consent of school.

An intense theoretical survey of terrestrial geophysics. Topics include potential theory, shape of the earth and physical geodesy.

Geol. 6052. Geophysics III – Geomagnetism and Paleomagnetism

3-0-3. Prerequisite: Geol. 6051 or consent of school.

Topics include magneto-hydrodynamics, origin and description of Earth's magnetic field, rock magnetism, remanent magnetism, geophysical evidence for global tectonics and tectonic mechanisms.

Geol. 6100. Clay Mineralogy

3-0-3. Prerequisite: consent of school.

The composition and structure of clay minerals, physical and chemical properties, x-ray identification, geologic distribution and significance, origin, clay-water relations.

Geol. 6110. Advanced Clay Mineralogy

2-3-3. Prerequisite: Geol. 6100.

Continuation of Geol. 6100, emphasizing effects of crystal structure and composition on physical and chemical properties. Laboratory involves x-ray, electron microscope and other techniques.

Geol. 6150. Sedimentary Geology

3-3-4. Prerequisite: Geol. 2500.

Composition and texture of

sediments and sedimentary rocks, sedimentary processes, primary sedimentary structures, weathering, transportation, diagenesis, environments of deposition, stratigraphy of sedimentary rocks.

Geol. 6160. Stratigraphy and Sedimentation

3-0-3. Prerequisite: Geol. 6150.

Continuation of Geol. 6150 with emphasis on sedimentary environments, recent and ancient. Principles of correlation, stratigraphic mapping and stratigraphic analysis.

Geol. 6180. Geology of Ground Water

3-0-3. Prerequisite: Geol. 2500.

Geol. 6210. Global Tectonics

3-0-3. Prerequisite: Geol. 4200.

Geological aspects of the new global tectonics.

Geol. 6220. Advanced Structural Geology

3-0-3. Prerequisite: Geol. 4200.

Geol. 6300. Principles of Physical Oceanography

3-0-3. Prerequisite: consent of school.

Temperature, salinity and density in the oceans. Dynamics of ocean currents. Theory of ocean waves. Selected topics with application to coastal and estuarine circulation.

Text: at the level of Neumann and Pierson, *Principles of Physical Oceanography*.

Geol. 6310. Principles of Chemical Oceanography

3-0-3. Prerequisite: Chem. 3412, Geol. 4300 or consent of school.

Brief overview of the chemistry of sea water and marine sediments. Detailed discussion of selected topics.

Geol. 6350. Ocean Acoustics

3-0-3. Prerequisites: Math. 4582, 4321. Recommended: Geol. 4300, A.E. 6760.

Propagation of sound waves in the ocean. Stress-strain relationships, asymptotic ray theory. Propagation in shallow and deep water. Irregularities of the media and boundaries.

Geol. 6400. Igneous Petrology

3-4-4. Prerequisite: Chem. 3412, Geol. 4400.

Microscopic study, classification, physical chemistry and evolution of igneous rocks.

Geol. 6450. Metamorphic Petrology

3-4-4. Prerequisite: Chem. 3412, Geol. 4400.

Study and classification of chemical and physical changes induced in rocks upon metamorphism. Microscopic laboratory study.

Geol. 6510. Analytical Methods in Geophysics I

3-3-4. Prerequisite: Geol. 6050, 6051.

Theory and practice in the application of numerical analysis methods to geophysical data. Topics include information theory in seismology and harmonic analysis of potential data.

Geol. 6520. Analytical Methods in Geophysics II

3-3-4. Prerequisite: Geol. 6050, 6051.

Theory of magnetotelluric and electromagnetic methods, conductivity of earth materials, theory of direct current resistivity, spontaneous potential and induced potential.

Geol. 6550. Observational Seismology

3-3-4. Prerequisite: Geol. 4500.

A study of the nature of earthquake motion and the damage it causes. The laboratory provides exercises in the interpretation of seismograms.

Geol. 6560. Theoretical Seismology

3-3-4. Prerequisite: Math. 4321, Geol. 6550.

Theory of elastic wave propagation in the earth. Topics include reflection of waves, surface waves, head waves and use of seismograms.

Geol. 6600. Aqueous Geochemistry

3-0-3. Prerequisite: Chem. 3412, Geol. 2500 or consent of school.

Reactions of minerals in earth surface and near-Earth-surface waters.

Geol. 6610. Organic Geochemistry

2-3-3. Prerequisite: Chem. 3313 or consent of school.

Geochemistry of organic substances. Diagenesis of organic matter. Chemical fossils. Chemical evolution on the primitive Earth. Methods of organic geochemical analysis.

Geol. 6620. Nuclear Geochemistry

3-0-3. Prerequisite: Phys. 2123, Geol. 3400 or consent of school.

Nuclear reactions and radioactive decay in nature. Origin of the nuclides. Age measurements based on radioactive decay. Natural variations in isotopic composition of elements.

Geol. 6750. Introductory Diffraction Studies

2-6-4. Prerequisite: consent of school.

Introductory theory and practice

of the most widely applicable x-ray and neutron diffraction techniques. Identification, lattice parameters, textures, line breadth and crystal orientation. Cross-listed with Phys. 4266.

Geol. 7000. Master's Thesis

Geol. 8000-1-2. Seminar
1-0-0 each.

Geol. 8101-2-3. Special Topics
2-0-2, 2-0-2, 3-0-3.

Geol. 8500-1-2-. Special Problems
Credit to be arranged.

Geol. 9000. Doctoral Thesis

Health Systems

H.S. 2011. Introduction to the Health Field
3-0-3.

Brief history of hospitals and medicine, the nature, problems and costs of modern health care institutions, proposed improvements and the role of health systems specialists.

Texts: at the level of Jones, editor, *The Health of Americans* and Lewin, editor, *The Nation's Health*.

H.S. 3011. Hospital Functions and Problems
3-0-3.

Internal structure, functions and management problems of hospitals, including departmental interactions, hospital and medical terminology, process flows of materials, supplies, personnel, patients, paperwork and information.

Texts: at the level of Sloane and Sloane, *A Guide to Health Facilities Personnel and Management* and Watt, *Introduction to a Typical U.S. General Hospital*.

H.S. 3021. Non-Hospital Components of the Health Care System
3-0-3.

Solo and group medical practice, office clinics, long-term hospitals, nursing homes and neighborhood clinics, health care finance, prepayment plans, insurance and the role of government.

H.S. 3111. Methods Improvement in the Health Services
3-0-3.

Work simplification, operations analysis, multiple activity charting, methods design, forms design, paperwork simplification, job analysis and evaluation, incentive plans, merit rating and employee suggestion plans. Not open to H.S. majors.

Text: at the level of Bennett, *Methods Improvement in Hospitals*.

H.S. 3121. Work Measurement in the Health Services
3-0-3. Prerequisite: H.S. 3011, I.Sy.E. 3015 and M.Sci. 3110, or equivalents.

Applications of time study, predetermined motion-times, statistical methods, evaluating alternative work methods, work sampling, standard data, scheduling, forms design and staffing methodologies to health-field problems.

H.S. 3131. Health Systems, Processes and Facilities
2-3-3. Prerequisite: H.S. 3121.

Inputs, outputs and interrelationships of work systems, processes, queues, line balancing, production, inventory and quality control, proximity analysis, layout and arrangement, critical path methods.

H.S. 3211. Data Processing in the Health Services

3-0-3. Prerequisite: H.S. 3011, I.C.S. 2700 or Mgt. 3050, Mgt. 3700.

Hospital and medical information systems, data collection, storage, processing and reporting, file design, record structure, processing requirements, controls, report formats, medical records, statistical audits, other applications.

Text: at the level of Bekey and Schwartz, *Hospital Information Systems*.

H.S. 3351. Health Systems Projects and Reports

3-0-3. Prerequisite: H.S. 2011 or consent of department.

Methods and techniques of proposing, planning, conducting and reporting health systems projects, the scientific method, interpersonal relationships and ethics, written and oral expression, audiovisual practice.

Text: at the level of Smalley and Freeman, *Hospital Industrial Engineering*.

H.S. 3971-2-3. Special Problems

Credit to be arranged. Prerequisite: prior arrangements with department.

Individual student projects that apply systems techniques to health care management problems with emphasis upon student initiative, methodology, problem solution and written report.

Text: at the level of HSRC Field Training Manual.

H.S. 4141. Health Facility Planning

2-3-3. Prerequisite: normally taken by seniors.

Methods and techniques of proximity analysis, layout, costing, economic evaluation, materials

handling, logistical support, automation, architecture and construction, shared services and community health planning.

H.S. 4471-2-3. Health Systems Practicums

0-12-4 each. Prerequisite: H.S. 3131, 3211, 3351.

Field training for individual students in actual health care institutions within commuting distance of campus in each of the senior year quarters, projects and reports.

Text: at the level of HSRC Field Training Manual.

H.S. 4581. Health Systems Externship

0-36-12. Prerequisite: H.S. 3131, 3211, 3351.

Three months of full-time field-training experiences for individual students in actual health care institutions or agencies affiliated with HSRC, projects and reports.

Text: at the level of HSRC Field Training Manual.

H.S. 4691. Health Systems Seminar

2-0-2. Prerequisite: H.S. 4471 or 4581.

Guest speakers, discussions of health systems issues and problems, techniques for achieving results, overcoming resistance to change, review of field training experiences, employment opportunities.

H.S. 4765. Hospital Management Systems

3-0-3. Prerequisite: normally taken by seniors.

Case studies of hospital management systems improvement through the application of industrial engineering and health systems principles and tech-

niques. Crosslisted as I.Sy.E. 4765, may be taken for graduate credit.

Text: at the level of Smalley and Freeman, *Hospital Industrial Engineering*.

H.S. 4861-2-3. Health Systems Topics

3-0-3 each. Prerequisite: consent of department.

Provides formal coursework on special topics not included in regular health systems courses.

H.S. 6765. Case Studies in Hospital Management Systems

3-0-3. Prerequisite: H.S. 4765 or equivalent.

A study of complex problems facing hospital management, the systems approach to their solution and critical reviews of studies reported in the technical literature. Crosslisted as I.Sy.E. 6765.

H.S. 7765. Projects in Hospital Management Systems

1-6-3. Prerequisite: H.S. 6765 or equivalent.

Individual student projects in actual hospital situations under faculty direction, with emphasis upon unusual applications of industrial engineering and health systems to hospital management problems. Crosslisted as I.Sy.E. 7765.

Industrial Management

Economics

Econ. 2000. Principles of Economics I

3-0-3. Prerequisite: sophomore standing.

The behavior of economic units in pricing and output decisions.

Econ. 2001. Principles of Economics II

3-0-3. Prerequisite: sophomore standing.

Surveys national income, employment, money and banking and international trade. Relates consumer, business, government and international sectors to the aggregate economy.

Econ. 3000. Economic Theory of the Firm

3-0-3. Prerequisite: Econ. 2000-1.

Intermediate price theory with applications to management problems.

Econ. 3001. National Income Analysis

3-0-3. Prerequisite: Econ. 2000-1.

An intermediate macro-economic theory course to enable the student to analyze the national economic environment relative to the firm and stabilization of the national economy.

Econ. 3002. Money and Banking

3-0-3. Prerequisite: Econ. 2000-1.

An analysis of how money fits into the economic system and the problems of administering monetary policy both domestically and internationally.

Econ. 3095. Seminar in Economic Policy

3-0-3. Prerequisite: Econ. 3000-1.

Topics for discussion will be chosen to encourage the student to focus his understanding of economic theory on a substantive problem. Designed for economics majors.

Econ. 3100. Econometrics I

3-0-3. Prerequisite: M. Sci. 3111.

An introduction to the statistical methods for estimating the quantitative relationships among

economic variables. Topics include model specification, parameter estimation, prediction and verification.

Econ. 3400. The Process of American Industrial Development
3-0-3. Prerequisite: Econ. 2000-1.

The forces, unique characteristics and problems associated with American industrialization.

Econ. 3401. European Economic History

3-0-3. Prerequisite: Econ. 2000-1.

An economic survey of the major institutions, inventions and innovations of the commercial revolution, the agricultural revolution and the industrial revolution in Europe.

Econ. 3410. Economic Development

3-0-3. Prerequisite: Econ. 2000-1.

General theories of economic development. Each student will be required to analyze the economy of a developing country.

Econ. 3500. Scope and Method of Political Economy

3-0-3. Prerequisite: Econ. 2000-1.

The logical structure of scientific theory as it applies to knowledge about political and economic situations and events.

Econ. 3501. Political Economy: Public Policy Analysis I

3-0-3. Prerequisite: Econ. 2000-1.

A theoretical perspective to explain and predict the effects of actual and proposed public policy and to generate some standards of evaluation.

Econ. 3502. Political Economy: Public Policy Analysis II

3-0-3. Prerequisite: Econ. 3501.

Uses the theoretical tools that Public Policy Analysis I develops to

analyze and evaluate specific areas of public policy.

Econ. 4000. Topics in Advanced Microeconomics

3-0-3. Prerequisite: Econ. 3000-1.

Selected topics in advanced microeconomics for economics majors.

Econ. 4050. Monetary Theory and Policy

3-0-3. Prerequisite: Econ. 3001.

Determinants of supply and demand for money and the effect of changes in these determinants on interest rates, prices and the level of national income.

Econ. 4100. Econometrics II

3-0-3. Prerequisite: Econ. 3100.

A detailed discussion of the problems encountered in empirical econometric studies. Emphasis is placed on data problems and errors in estimation and prediction.

Econ. 4110. Mathematical Economics

3-0-3. Prerequisite: Econ. 2000-1.

This course emphasizes the application of mathematical tools to economic analysis. Topics include mathematical programming, game theory, difference and differential equations and optimal control theory.

Econ. 4120. Economic Forecasting

3-0-3. Prerequisite: Econ. 2000-1.

Cyclical fluctuations in the total economy are examined empirically. Methods of making forecasts of national and industry performance are presented.

Econ. 4230. Economics of the Labor Market

3-0-3.

The application of micro-

economic theory to wages, employment and productivity.

Econ. 4231. Labor History

3-0-3.

A survey of the times and conditions facing the working class in attempting to establish a body of industrial jurisprudence.

Econ. 4235. Protective Labor Legislation

3-0-3.

Federal and state regulation of worker security against occupational injury, unemployment, old-age, disability and discrimination, plus wage and hour legislation.

Econ. 4265. U.S. Labor Relations Law

3-0-3. Prerequisite: Mgt. 4200.

An examination of labor legislation, court decisions and NLRB rulings on labor-management relations.

Econ. 4300. International Economics

3-0-3. Prerequisite: two of Econ. 3000-1-2.

Foreign trade and commercial policy, international finance and current problems of international economic relations.

Econ. 4310. Public Finance

3-0-3. Prerequisite: Econ. 2000-1.

Analyzes government's role in resource allocation, income distribution, stabilization and growth through the economic effects of government spending and revenue raising activities.

Econ. 4320. Managerial Economics

3-0-3. Prerequisite: Econ. 3000.

Relationships between economic concepts and managerial

decisions. Topics covered include non-profit goals of the firm, unstructured managerial problems and the determinants of good managerial decisions.

Econ. 4330. Regional Economics

3-0-3. Prerequisite: Econ. 2000-1.

Theories of regional income determination and regional growth, spatial economic structure, central-place theory and regional effects of public policy.

Econ. 4331. Urban Economics

3-0-3. Prerequisite: Econ. 2000-1.

The economic dimensions of the processes and problems associated with urbanization are examined in this course.

Econ. 4332. Economics of Location

3-0-3. Prerequisite: Econ. 3000.

A survey of economic factors influencing industrial location. Consideration will be given locational patterns, the impact of transfer processing costs and land use competition.

Econ. 4340. Economics of Industrial Competition

3-0-3. Prerequisite: Econ. 2000-1.

The competitive structure of the American economy in terms of economic models, alternative public policy goals and the development of anti-trust laws.

Econ. 4341. Economics of Regulated Industries

3-0-3. Prerequisite: Econ. 2000-1.

The problems and policy options associated with government regulation of particular industries.

Econ. 4400. History of Economic Thought

3-0-3. Prerequisite: Econ. 2000-1.

A historical survey of schools of economic thought. The main body

of the course is concerned with classical, neoclassical, Marxist, Keynesian and modern economic thought.

Econ. 4410. Industrial Development in Latin America

3-0-3. Prerequisite: Econ. 2000-1.

The principles of industrial development in emerging nations. The student prepares an analysis of the problems in a specific Latin American country.

Econ. 4420. Comparative Economic Systems

3-0-3. Prerequisite: Econ. 2000-1.

A critical study is made of the methods by which various economic systems meet common fundamental problems in production, exchange, distribution and capital formation.

Econ. 4500. Political Economy: Non-Market Decision Making I

3-0-3. Prerequisite: Econ. 2000-1.

Collective choice through an economic-rational choice perspective, seeking to explain and predict the relationships among campaigns, voting and public policy toward private enterprise.

Econ. 4501. Political Economy: Non-Market Decision Processes II

3-0-3.

The economics and politics of change, technological progress, price effects on innovation and trade-offs between economic efficiency and political expediency in national policies for energy, research, etc.

Econ. 4801-2-3. Special Topics in Economics

3-0-3 each.

A course designed to permit students to pursue a specialized interest in an area of economics

not extensively treated in the offerings of the college.

Econ. 4901-2-3. Individual Research in Economics

Credit to be arranged.

Designed to permit independent study with a faculty member. To register, a professor's approval in writing of a research proposal must be obtained.

Econ. 4990. Georgia Internship Program

Credit to be arranged. Prerequisite: consent of college.

Broadens the scope of the college curriculum by offering students a community-based learning experience which stresses the completion of a specific task.

Econ. 6000. Microeconomic Analysis and Policy

3-0-3.

Theoretical analysis of the determination of prices and output. The objective is to develop the basic economic concepts.

Econ. 6001. Macroeconomic Analysis and Policy

3-0-3.

National income accounting methods and the theory of national income determination.

Econ. 6002. Applied Welfare Economics

3-0-3. Prerequisite: Econ. 6001.

Offers to non-economists, as well as to economists, an opportunity to broaden their decision-making framework by stressing the role and contribution of economic theory.

Econ. 6050. Monetary Theory

3-0-3. Prerequisite: Econ. 6001.

Theories of the role of money

and the monetary system in economic stabilization and growth, analyses of monetary and fiscal policies.

Econ. 6120. Economic Forecasting

3-0-3. Prerequisite: Econ. 6001 or equivalent.

Macroeconomic theory and the analysis of overall economic conditions with their application to management problems of the industrial firm.

Econ. 6230. Labor and the Economy

3-0-3. Prerequisite: previous course in labor relations.

Case course involving contract negotiations, grievance handling and arbitration.

Econ. 6266. Wage and Employment Theory

3-0-3. Prerequisite: Econ. 6000, 6001.

An analysis of the economic theories and institutional developments explaining the terms, conditions and levels of employment.

Econ. 6300. International Trade and Finance

3-0-3. Prerequisite: Econ. 6001.

Foreign exchange market, foreign trade and commercial policy, international finance and current problems of international economics.

Econ. 6320. Managerial Economics

3-0-3. Prerequisite: Econ. 6000.

Relationships between economic concepts and managerial decisions. Topics covered include non-profit goals of the firm, unstructured managerial problems and the determinants of good managerial decisions.

Econ. 6330. Regional Economics
3-0-3.

Survey of the economics of regions, emphasizing region delineation, systems of cities, measurement of regional activity, theories of income, employment and economic growth.

Econ. 6331. Economics of Industrialization

3-0-3.

An examination of long-run growth processes seeking causes of under-development, exploring theories of economic growth and applying these explanations to developed and underdeveloped economies.

Econ. 6335. The Economics of Environmental Quality

3-0-3. Prerequisite: consent of college.

Topics included are the causes of market failure to provide a high quality environment, amenity resources and extra-market values.

Econ. 6340. Industry and Government

3-0-3. Prerequisite: Econ. 6000 or equivalent.

Organization and the structure of American industry, beginning with price theory under various forms of market structure.

Econ. 6400. Public Issues in Economic Policy

3-0-3.

Major public issues from the viewpoint of American economic history.

Econ. 6410. Development of Economic Thought

3-0-3. Prerequisite: Econ. 6000-1, consent of college.

Development of the various schools of economic thought and

their contributions to the present body of economic theories. Credit not given for both Econ. 4400 and 6410.

Econ. 6430. Research Methods in Development

3-0-3.

General review of research techniques and to acquaint the student with the literature and reference sources in industrial development.

Econ. 6435. Development Seminar I

1-0-1. Prerequisite: Econ. 6410.

Planning and researching a project in industrial development.

Econ. 6436. Development Seminar II

3-0-3. Prerequisite: Econ. 6435.

Writing and presenting a research paper on industrial development. The paper may be either applied or theoretical in nature and should be of publishable quality.

Econ. 6500. Non-market Processes and Economic Decisions

3-0-3. Prerequisite: consent of college.

Development of political economy and relation of political-economic processes to managerial decision-making.

Econ. 6501. Private and Public Spheres of Influence

3-0-3.

Processes of private and public decisions in a modern economy.

Econ. 6760. Financial Management and Economics of Nuclear Power

3-0-3.

Interdisciplinary relationship of the nuclear fuel cycle and reactor system to the electrical power industry treated as a system, effect

of management decisions on the overall economics. Also listed at N.E. 6760.

Econ. 7000. Advanced Micro-economic Analysis

3-0-3. Prerequisite: Econ. 6000 or equivalent and consent of college.

Analysis of resource allocation and income distribution.

Econ. 7001. Advanced Macro-economic Analysis

3-0-3. Prerequisite: Econ. 6001 or equivalent and consent of college.

Interrelationships among the major aggregated sectors of a national economy taking special cognizance of institutions which exist in U.S.

Econ. 7002. Seminar in Micro-economics

3-0-3. Prerequisite: Econ. 7000 and consent of college.

Students have an opportunity to pursue in depth some topic or problem in the area of micro-economics.

Econ. 7003. Seminar in Macro-economics

3-0-3. Prerequisite: Econ. 7001 and consent of college.

Students have an opportunity to pursue in depth some topic in the area of macroeconomics.

Econ. 7100. Econometrics

3-0-3. Prerequisite: consent of college.

An analysis of the problems of heteroscedasticity, multicollinearity, underidentification and autocorrelation as whole.

Econ. 7101. Seminar in Econometrics

3-0-3. Prerequisite: Econ. 7100 and consent of college.

Empirical economic research.

Econ. 8401. Special Topics

1-0-1. Prerequisite: consent of college.

Topics of current interest in the field of economics.

Econ. 8402. Special Topics

2-0-2. Prerequisite: consent of college.

Topics of current interest in the field of economics.

Econ. 8403. Special Topics

3-0-3. Prerequisite: consent of college.

Topics of current interest in the field of economics.

Econ. 8404. Special Topics

4-0-4. Prerequisite: consent of college.

Topics of current interest in the field of economics.

Econ. 8405. Special Topics

5-0-5. Prerequisite: consent of college.

Topics of current interest in the field of economics.

Econ. 8406. Special Topics

6-0-6. Prerequisite: consent of college.

Topics of current interest in the field of economics.

Econ. 8501-2-3-4-5-6. Special Problems

Credit to be arranged. Prerequisite: consent of the college.

Provides project work experience in the field of economics.

Econ. 9000. Doctoral Thesis

Industrial Management

Mgt. 2000-1-2. Accounting I, II, III

3-0-3 each. Prerequisite: sophomore standing.

Provide a basic understanding

of general and cost accounting systems and the utilization of reported financial information.

Mgt. 3010. Taxation

3-0-3. Prerequisite: Mgt. 2000.

Business income tax requirements and the management planning necessitated by various tax alternatives. Some attention to personal income taxes.

Mgt. 3050. Computer-based Management Systems

3-0-3. Prerequisite: M. Sci. 2000.

An introduction to concepts used in the design of management systems relying on computers and information technology.

Mgt. 3060. Finance I

3-0-3. Prerequisite: Econ. 2000, Mgt. 2001.

Introduces the institutions and instruments for acquisition of funds, and stresses their utilization within an economic environment for making financial decisions.

Mgt. 3061. Finance II

3-0-3. Prerequisite: Mgt. 3060.

Application of capital budgeting techniques to the firm, including selection from alternative investment opportunities, determining cost of capital and treatment of uncertainty.

Mgt. 3070. Management Science Models in Finance

3-0-3. Prerequisite: Mgt. 3060.

A study of the analytical techniques in finance including capital budgeting, portfolio theory and capital market theory.

Mgt. 3080. Investments

3-0-3. Prerequisite: Mgt. 3060 or 3701.

An introduction from a theoretical point of view to the selec-

tion and acquisition of proper securities for managing portfolios with different goals.

Mgt. 3100. Organizational Development

3-0-3. Prerequisite: Mgt. 3150 or consent of college.

Analysis of the structural development of the organization. Particular emphasis is given to organization-environment interfaces, effectiveness and efficiency. Managing technology and change.

Mgt. 3150. Management Theory

3-0-3.

Provides students with a fundamental management theory matrix essential to the understanding of management, process and role.

Mgt. 3160. Management in a Changing Society

3-0-3.

Role of the manager in today's era of pervasive change, viewing the firm as a socio-economic agent of the society.

Mgt. 3161. Management as a Creative Force

3-0-3. Prerequisite: Mgt. 3160.

Describes the manager's role in accomplishing the entrepreneurial mission of the enterprise. Each student analyzes and reports on an existing organization.

Mgt. 3260. Law I

3-0-3.

Development and function of the law, court organization, procedure and substantive law in contracts, business organizations and agency.

Mgt. 3261. Law II

3-0-3.

Legal problems encountered in an urban environment within a

socio-economic and political atmosphere, specifically in the areas of consumer problems, bankruptcy and constitutional law.

Mgt. 3300. Marketing I

3-0-3. Prerequisite: Econ. 2000.

Marketing's role in the productive process, basic buyer behavior, market segmentation concepts, the management of marketing activities, environmental influences on marketing management.

Mgt. 3301. Marketing Management

3-0-3. Prerequisite: Mgt. 3300.

Emphasis of marketing management problems through the process of analysis, planning and control, case analysis and readings.

Mgt. 3310. Marketing Research

3-0-3. Prerequisite: Mgt. 3300.

Research orientation, planning an investigation, questionnaires, sampling, interpretation of results, report presentation.

Mgt. 3320. Management Science Models in Marketing

3-0-3. Prerequisite: Mgt. 3300.

The use of management science models to solve marketing management problems, application rather than theory is stressed.

Mgt. 3330. Contemporary Issues in Marketing

3-0-3. Prerequisite: Mgt. 3300.

Course is designed to encourage students to examine the principles of marketing in light of contemporary thinking concerning social, economic and technological development.

Mgt. 3700. Analysis of Financial Data

3-3-4. Not open to College of I.M. undergraduates.

A survey of general and cost systems. Emphasis on the use of accounting data. Credit not given for Mgt. 3700 and any other undergraduate accounting course.

Mgt. 3701. Finance Survey

3-0-3. Not open to any I.M. student except B.M.G.T. majors.

Covers the more popular types of business organizations, with emphasis on the corporation, its organization, management and types of securities issued. Credit cannot be given for Mgt. 3701 and either Mgt. 3060 or 3061.

Mgt. 4020. Auditing and Accounting Systems

3-0-3. Prerequisite: Mgt. 2001, 3060.

Emphasizes both the design of accounting systems and external and internal auditing and control procedures.

Mgt. 4100. Organizational Analysis

3-0-3. Prerequisite: Mgt. 3150 or consent of college.

Analysis of internal outcomes of the organizing process. The individual-organization interface is studied to understand perception, motivation, group formation and leadership within the firm.

Mgt. 4110. The Management of Organized Effort

3-0-3. Prerequisite: normally taken by seniors.

Management as a process of developing and controlling situations toward which people act and respond, both individually and as members of groups.

Mgt. 4115. Contemporary Management Thought

3-0-3. Prerequisite: Mgt. 3150 or consent of college.

This course emphasizes the impact of changing social values on

management thought and practices. Guest speakers make important contributions to the course.

Mgt. 4120. Contemporary Research in Management

3-0-3. Prerequisite: either Mgt. 3100, 4100 or consent of college.

Investigations, analysis, critiques and reports of current research orientations in management. Students learn how management research is done.

Mgt. 4140. Personnel Management Problems

3-0-3. Prerequisite: Mgt. 3150 or consent of college.

Analysis of the personnel management process with emphasis placed upon the role and contribution to the firm of the staff function of personnel administration.

Mgt. 4151. Management of Industrial Research and Development Programs

3-0-3. Normally taken by seniors.

Analysis of managerial considerations involved in conducting industrial, basic and applied research programs and their integration with marketing, manufacturing and finance activities of the firm.

Mgt. 4160. Management Concepts and Issues in World Business

3-0-3. Normally taken by seniors.

Covers significant aspects of international business, changing patterns of world industry, emergence of common markets, role of U.S. industry overseas.

Mgt. 4165. Seminar

1-0-1. Junior standing.

Lectures and discussions with prominent business, government, labor and educational leaders. Offered winter quarter only.

Mgt. 4170. Career Analysis

3-0-3.

A course designed to enable students to analyze classified jobs in a company to determine career paths, training provided and counseling for workers.

Mgt. 4180. Industrial Management Honors Seminar

3-0-3. Last or next to last quarter seniors by faculty invitation.

Gives outstanding seniors an opportunity to research, analyze and discuss current management and economic problems.

Mgt. 4195. Integrated Management Problems

3-0-3. Prerequisite: senior standing and completion of Mgt. 3150, 3300, a marketing elective, Mgt. 3061 or 3070 and 4350.

Comprehensive cases are used to integrate knowledge at the policy level of management and to relate managerial decisions to the economic and competitive forces affecting business.

Mgt. 4200. Industrial Relations

3-0-3.

Theories of the labor movement, union-management relationship, including the legal setting, contract negotiations, contract administration and the roles and nature of third parties.

Mgt. 4201. Contemporary Unionism and Collective Bargaining

3-0-3. Prerequisite: Mgt. 4200.

A study of union structure, collective bargaining procedures and the analysis of union-management contracts.

Mgt. 4202. Cases in Labor-Management Relations

3-0-3. Prerequisite: Mgt. 4200.

A case study of problem areas in

union-management relations. The cases used will be actual NLRB and labor arbitration decisions.

Mgt. 4230. Economics of the Labor Market

3-0-3.

The application of micro-economic theory to wages, employment and productivity.

Mgt. 4231. Labor History

3-0-3.

A survey of the times and conditions facing the working class in attempting to establish a body of industrial jurisprudence.

Mgt. 4235. Protective Labor Legislation

3-0-3.

Federal and state regulation of worker security against occupational injury, unemployment, old-age, disability and discrimination, plus wage and hour legislation.

Mgt. 4250. Nonmarket Environment of the Firm

3-0-3. Normally taken by seniors.

An examination of the socio-cultural factors which must be taken into account in the management decision process and of the forces which lead to their change through time.

Mgt. 4265. U.S. Labor Relations Law

3-0-3. Prerequisite: Mgt. 4200.

An examination of labor legislation, court decisions and NLRB rulings on labor-management relations.

Mgt. 4290. Public Administration

3-0-3.

An examination of the managerial function of federal, state, and local governments with

emphasis on the role of their interaction with the private sector.

Mgt. 4331. Consumer Behavior

3-0-3. Prerequisite: Mgt. 3300.

Stresses the impact of buyer decisions on the firm's marketing functions. Discusses economic, psychological, sociological, anthropological and organization impacts on buyer decisions.

Mgt. 4335. International Marketing

3-0-3. Prerequisite: Mgt. 3300.

Emphasis on international comparative analysis, the role of marketing in economic development and marketing strategies and policies of multinational firms.

Mgt. 4350. Production Management I

3-0-3. Prerequisite: Mgt. 3150, Econ. 3000.

Develops understanding of the organizational, economic and physical framework within which the manufacturing division functions.

Mgt. 4801-2-3. Special Topics in Industrial Management

3-0-3 each.

Permits groups of students to pursue areas of management not extensively treated in other courses or to engage in minor research or special problems.

Mgt. 4901-2-3. Individual Research in Industrial Management

Credit to be arranged.

Designed to permit independent study with a faculty member. To register, a professor's approval in writing of a research proposal must be obtained.

Mgt. 4990. Georgia Internship Program

Credit to be arranged. Prerequisite: consent of college.

Broaden the scope of the college curriculum by offering students a community-based learning experience which stresses the completion of a specific task.

Mgt. 6000. Management Accounting and Control

3-0-3. Prerequisite: consent of college.

Cover the use of accounting systems to provide information for performance evaluation.

Mgt. 6001. Budgetary Processes

3-0-3. Prerequisite: Mgt. 6000 or equivalent, consent of college.

Develop the concepts of planning, budgeting and control as they relate to large resource allocation decisions.

Mgt. 6030. Financial Control I

4-0-4.

The general and cost accounting system of the firm will be studied as a managerial information system.

Mgt. 6031. Financial Control II

3-0-3. Prerequisite: Mgt. 6030 or equivalent.

Principles, problems and methods of accumulating, analyzing and interpreting accounting data.

Mgt. 6032. Financial Control III

3-0-3. Prerequisite: Mgt. 6031 or equivalent.

Applies decision principles developed in Mgt. 6031.

Mgt. 6060. Financial Management I

3-0-3. Prerequisite: graduate standing and Mgt. 6000 or equivalent.

Instruments and institutions of finance, the creation and modifica-

tion of the financial structure of the firm.

Mgt. 6061. Financial Management II
3-0-3. Prerequisite: Mgt. 6060.

Procurement and the application of funds within the firm in a manner consistent with predetermined objectives.

Mgt. 6100. Organization Processes

3-0-3. Prerequisite: consent of college.

Introduction to analysis of individual behavior and to individual and group performance in organizations.

Mgt. 6101. Organizational Problems, Theory and Application

3-0-3. Prerequisite: consent of college.

Introduction to, and analysis of, various theories of organization in terms of goals, form and social setting. Organizational design-performance relationships are key issues considered.

Mgt. 6105. Individuals in Organizations

3-0-3. Prerequisite: graduate standing, consent of college.

Combines the theory of management with a workable knowledge of the behavioral sciences in achieving the objectives of management.

Mgt. 6106. Group Processes in Organizations

3-0-3. Prerequisite: Mgt. 6105.

Administrative problems that arise in the relationships among people in organizations.

Mgt. 6107. Organization Theory
3-0-3.

Background for student to build sound organizational structure

within the objectives of the enterprise.

Mgt. 6140. Management Systems Analysis

3-0-3. Prerequisite: basic knowledge of computers, accounting and management operations.

Concepts and techniques of managerial process simulation, analysis of computer-based management information and control systems.

Mgt. 6155. Development of Management Thought

3-0-3.

A survey of the development of management thought based upon a critical examination of classic works in management literature.

Mgt. 6160. Management Theory

3-0-3. Prerequisite: consent of college.

Provides resources essential to the development of a matrix of management theory at the professional level.

Mgt. 6170. The Entrepreneur, Innovation and Change

3-0-3.

The role of the entrepreneur and innovation in economic development.

Mgt. 6180. Multinational Business

3-0-3. Prerequisite: consent of department.

Critical examination of business concepts, organizational structures and control processes of the multinational corporation in different political and economic environments.

Mgt. 6195. Managerial Policy

3-0-3. Prerequisite: accounting, finance, marketing and production.

Economic, competitive and governmental forces affecting managerial decision-making. Should not be taken until the student's last quarter.

Mgt. 6200. Labor Problems

3-0-3.

An examination of the union-management relationship. Includes analysis of labor agreements, grievance procedures and arbitration and the legal environment of labor relations.

Mgt. 6260. The Legal Environment

3-0-3.

The role of law in society, legal philosophy and basic legal concepts.

Mgt. 6300. Marketing Management I

3-0-3.

Critical analysis of the marketing functions of an industrial enterprise, organizing and control of marketing programs emphasized.

Mgt. 6301. Marketing Management II

3-0-3. Prerequisite: Mgt. 6300.

Advanced course in marketing analysis and strategy formulation. Particular emphasis will be given to application of materials from Mgt. 6300.

Mgt. 6310. Marketing Research and Analysis

3-0-3. Prerequisite: Mgt. 6300 or equivalent.

Theory and techniques of marketing analysis and its use in the formulation of policy and strategy.

Mgt. 6320. Marketing Models

3-0-3. Prerequisite: Mgt. 6300 and a knowledge of probability and statistics.

Marketing models utilizing

probability and statistics as well as behavioral techniques.

Mgt. 6330. Consumerism and Public Policy Issues in Marketing

3-0-3. Corequisite: Mgt. 6300.

Recent issues in consumerism, the performance of marketing activity within our society.

Mgt. 6350. Manufacturing Management I

3-0-3.

Provides the student an opportunity to combine the theories of economics and management in the production of manufactured products.

Mgt. 6351. Manufacturing Management II

3-0-3. Prerequisite: Mgt. 6350.

Further development and application of managerial and economic concepts in the solution of problems in the manufacturing firm.

Mgt. 7000. Master's Thesis

Mgt. 7090. Management Research Methods

3-0-3. Prerequisite: consent of college.

Seminar in research techniques being employed in the current literature of management and economics.

Mgt. 7091. Seminar in Management and Economic Research

3-0-3. Prerequisite: consent of college.

Student pursues his primary area of interest to prepare a formal plan for his future research.

Mgt. 7140. Management Systems Theory

3-0-3. Prerequisite: consent of college.

Fosters the investigation of

managerial relationships existing among the diverse elements.

Mgt. 7750. Seminar on Psychology and Management

3-0-3. Prerequisite: Psy. 6601 or 6609, Mgt. 6150 or 6105, or equivalent and consent of college.

Selected management problems involving psychological complexities, individual behavior in an organizational setting. Also listed as Psy. 7750.

Mgt. 8401. Special Topics

1-0-1. Prerequisite: consent of college.

Topics of current interest in the field of management.

Mgt. 8402. Special Topics

2-0-2. Prerequisite: consent of college.

Topics of current interest in the field of management.

Mgt. 8403. Special Topics

3-0-3. Prerequisite: consent of college.

Topics of current interest in the field of management.

Mgt. 8404. Special Topics

4-0-4. Prerequisite: consent of college.

Topics of current interest in the field of management.

Mgt. 8405. Special Topics

5-0-5. Prerequisite: consent of college.

Topics of current interest in the field of management.

Mgt. 8406. Special Topics

6-0-6. Prerequisite: consent of college.

Topics of current interest in the field of management.

Mgt. 8501-2-3-4-5-6. Special Problems

Credit to be arranged. Prerequisite: consent of college.

Provides project work experience in the field of management.

Mgt. 8801-2-3-4. Management Research

Credit to be arranged.

Credit given for the presentation of a satisfactory written report embodying the results of intensive research and study of a management problem. Conferences will be arranged.

Mgt. 9000. Doctoral Thesis

Management Science

M.Sci. 2000. Management Applications of Data Processing

2-3-3. Prerequisite: sophomore standing.

Provides a technical foundation for the development of computer-based management systems.

M.Sci. 3100. Survey of Statistics

3-0-3. Prerequisite: Math. 1711.

A survey of discrete probability and statistics with emphasis on economic and business applications. Serves as core requirement for I.M. degree.

M.Sci. 3110. Statistics I

3-0-3. Prerequisite: Math. 1713, 1711.

Emphasis on continuous probability models and discrete models. Required of economics majors and recommended to those wanting a two course sequence in statistics.

M.Sci. 3111. Statistics II

3-0-3. Prerequisite: Math. 1713, 1711.

Classical inference and estima-

tion drawing heavily on calculus for such topics as maximum likelihood estimation, evaluation of decision rules, etc. Serves as core requirement for I.M. degree.

M.Sci. 3200. Management Science I
3-0-3.

Applications of linear programming to the analysis of managerial problems. Topics include duality, transportation problems, network flows, postoptimality analysis and decomposition.

M.Sci. 3201. Management Science II
3-0-3. Prerequisite: Math. 4215.

This second course in the methodology and application of management science is concerned with the use of stochastic models in the analysis of managerial and economic decision making.

M.Sci. 3300. Decision Analysis in Management
3-0-3. Prerequisite: Math. 1711.

An introduction to decision models for management situations under risk and uncertainty including fundamental economic concepts of a theory of rational choice.

M.Sci. 3400. Analytical Methods in Management I
3-0-3. Prerequisite: Math. 1711.

Introduction to management science. Analytical models of management decision situations. Topics include classical optimization and linear programming.

M.Sci. 3401. Analytical Methods in Management II
3-0-3. Prerequisite: M.Sci. 3400 or 3200.

Additional applications of linear programming to analysis of management decision problems. Topics include alternatives to the simplex algorithm.

M.Sci. 3402. Analytical Methods in Management III
3-0-3. Prerequisite: M.Sci. 3400 or 3200.

Introduction to the theory and applications of dynamic, integer and nonlinear programming in the analysis of management decision problems.

M.Sci. 3403. Analytical Methods in Management IV
3-0-3. Prerequisite: M.Sci. 3400, 3110.

Analytical and simulation approaches to the analysis of queueing and inventory systems.

M.Sci. 4100. Statistical Analysis
3-0-3. Prerequisite: consent of college.

Statistical fundamentals and techniques for graduate students with diverse backgrounds.

M.Sci. 4110. Introduction to Sampling
3-0-3. Prerequisite: statistical inference.

Theory and applications of sampling techniques with applications to substantive management and economic research problems.

Theory and applications of sampling techniques with applications to substantive management and economic research problems.

M.Sci. 4120. Nonparametric Statistics
3-0-3. Prerequisite: statistical inference.

A survey of some of the more widely used nonparametric statistical tests in management and economic research.

A survey of some of the more widely used nonparametric statistical tests in management and economic research.

M.Sci. 4801-2-3. Special Topics in Management Science
3-0-3 each. Normally taken by seniors.

Designed to permit independent study with a faculty member. To register, a professor's approval of

Designed to permit independent study with a faculty member. To register, a professor's approval of

a research proposal must be obtained in writing.

M.Sci. 4990. Georgia Internship Program

Credit to be arranged. Prerequisite: consent of college.

Broadens the scope of the college curriculum by offering students a community-based learning experience which stresses the completion of a specific task.

M.Sci. 4991-2-3. Special Problems

Credit to be arranged. Prerequisite: consent of college.

The special project is designed to provide the student an opportunity to apply his full training to the analysis of an applied or theoretical problem.

M.Sci. 6000. Quantitative Decision Procedures I

3-0-3. Prerequisite: consent of college.

Introduction to mathematical analysis of managerial and economic decision problems. Deterministic models and methods and some requisite mathematical concepts are studied.

M.Sci. 6010. Analytical Methods in Management

3-0-3.

Introduces beginning graduate students to scientific methods of decision-making in dealing with economics problems.

M.Sci. 6050. Management Systems and Information Technology

3-0-3. Prerequisite: consent of college.

Management use of information technology to capture, process and distribute information for support of managerial decision-making.

M.Sci. 6051. Computer Simulation of Management Problems

3-0-3. Prerequisite: M.Sci. 2000 or equivalent.

Techniques of simulating general management decisions utilizing information from the areas of marketing, production, finance and industrial relations.

M.Sci. 6101. Applications of Statistical Methods to Management Decision-making

3-0-3. Prerequisite: M.Sci. 4100 or equivalent.

Theory and applications of elementary multiple regression analysis and elementary statistical decision theory in a management framework.

M.Sci. 6102. Application of Regression Analysis

3-0-3. Prerequisite: M.Sci. 6101 or equivalent, matrix algebra.

Special problems in regression analysis as found in business, management and economics.

M.Sci. 6105. General Decision Theory: Utility and Games

3-0-3.

Models of nondeterministic decision situations. General finite games in extensive and normal forms, utility indicators, matrix games, mixed extensions, the fundamental theorem and computational techniques.

M.Sci. 6106. Applications of General Decision Theory in Management and Economics

3-0-3.

Risk games, statistical games, Bayes and minmax strategies, principle of choice problem, no data and data variants. Applications in management and economics.

M.Sci. 6410. Mathematical Programming

3-0-3. Prerequisite: M.Sci. 6010 or equivalent, consent of college.

The theory of mathematical programming and its applications in managerial planning, budgeting and decision making.

M.Sci. 6411. Seminar in Mathematical Programming

3-0-3. Prerequisite: M.Sci. 6410.

Student research and/or in-depth study of recent literature on theory and application of mathematical programming in management and economics.

M.Sci. 8401. Special Topics

1-0-1. Prerequisite: consent of college.

Topics of current interest in the field of management science.

M.Sci. 8402. Special Topics

2-0-2. Prerequisite: consent of college.

Topics of current interest in the field of management science.

M.Sci. 8403. Special Topics

3-0-3. Prerequisite: consent of college.

Topics of current interest in the field of management science.

M.Sci. 8404. Special Topics

4-0-4. Prerequisite: consent of college.

Topics of current interest in the field of management science.

M.Sci. 8405. Special Topics

5-0-5. Prerequisite: consent of college.

Topics of current interest in the field of management science.

M.Sci. 8406. Special Topics

6-0-6. Prerequisite: consent of college.

Topics of current interest in the field of management science.

M.Sci. 8501-2-3-4-5-6. Special Problems

Credit to be arranged. Prerequisite: consent of college.

Provides project work experience in the field of management science.

Industrial and Systems Engineering

I.Sy.E. 1010. Basic Concepts in Industrial and Systems Engineering

2-3-3. Available to freshmen only. May substitute for E. Gr. in B.I.E. curriculum.

Introduction to types of problems concerning industrial and systems engineers. Students develop solutions which are compared to typical analytical solution techniques encountered in I.Sy.E. practice.

I.Sy.E. 1729. Feedback Dynamics Approach to Social Systems Analysis and Engineering

3-0-3. Not available for credit to junior or senior I.Sy.E. students.

Philosophy and methodology of feedback dynamics applied to human systems analysis, relationship to philosophy and social sciences stressed, special topics developed, world dynamics, forecasting, education.

I.Sy.E. 2000. Introduction to Industrial and Systems Engineering

3-0-3.

The role of I.Sy.E. in industrial organizations and society. Introduction to I.Sy.E. philosophy and analytical methodologies. Outlines curricula for selection of field of student's specialization.

I.Sy.E. 2001. Projects

0-6-2. Available to I.Sy.E. students only, or consent of department.

Student group analysis of an unstructured problem situation. Requires students to identify, structure and analyze problem relationships within an off-campus working environment.

I.Sy.E. 3010. Man-machine Systems

3-0-3.

Introduction to methods for analysis and design of man-machine systems. Stresses quantitative techniques in analysis of work center design and work systems design.

I.Sy.E. 3013. Physiological and Biomechanical Analysis of Work

2-0-2. Prerequisite: I.Sy.E. 3010.

The physiological and biomechanical aspects of work analysis. Techniques of data collection and its analysis for effective, man-power oriented tool and work place design.

I.Sy.E. 3014. Systems and Productivity

3-0-3. Prerequisite: I.Sy.E. 3010, Psy. 4410.

Human contributions to productivity and interaction of technical advances with human performance. Examination of impact of individual needs, leadership styles and organizational design on productivity.

I.Sy.E. 3015. Analysis of Production Operations

4-0-4.

Analysis, synthesis and improvement of individual work operations within production systems. Emphasis on work measurement, data collection, work center design and work system design.

I.Sy.E. 3025. Engineering Economy

3-0-3. Corequisite: Mgt. 3700. Available to I.Sy.E. students only.

Methods of economic analysis in engineering including decision problems, value measurement, interest relationships, criteria for decisions under certainty, risk and uncertainty.

I.Sy.E. 3027. Applications of Probability

3-0-3. Prerequisite: Math. 2308.

Introduction to probability, emphasizing applications in science and engineering. Topics include probability concepts, random variables, discrete and continuous distributions.

I.Sy.E. 3028. Engineering Statistics I

3-0-3. Prerequisite: I.Sy.E. 3027 or equivalent.

Introduction to statistical methodology, emphasizing applications in science and engineering. Topics include estimation, hypothesis testing and process control.

I.Sy.E. 3029. Engineering Statistics II

3-0-3. Prerequisite: I.Sy.E. 3028 or equivalent.

Introduction to analysis of planned and unplanned experiments. Topics include regression and analysis of variance with applications to problems in engineering and science.

I.Sy.E. 3033. Deterministic Models in Operations Research

4-0-4. Prerequisite: Math. 2308.

Introduction to the methodology of operations research to solve engineering and management problems. Simplex methods, sensitivity analysis, duality, network

models, integer and dynamic programming.

I.Sy.E. 3034. Probabilistic Models in Operations Research

3-0-3. Prerequisite: I.Sy.E. 3033, 3027 or equivalent.

Continuation of I.Sy.E. 3033 emphasizing formulation and solution of models under uncertainty. Emphasizes dynamic programming, Markov chains, decision trees, inventory models and waiting line models.

I.Sy.E. 3080. Systems Engineering I
2-3-3. Prerequisite: Math. 2309 or equivalent.

Introduction to systems engineering and its methodological and conceptual foundations. Integrated use of mathematical and engineering concepts for analysis and design of interdisciplinary systems.

I.Sy.E. 3081. Systems Engineering II
3-0-3. Prerequisite: I.Sy.E. 3080.

Continuation of I.Sy.E. 3080 emphasizing systems engineering concepts in large scale interdisciplinary systems. Topics include modeling, decision theory, systems reliability and cost effectiveness studies.

I.Sy.E. 3090. Computer Methods in Systems Engineering

2-3-3. Prerequisite: I.Sy.E. 3080, I.C.S. 1700 or equivalent.

Simulation of systems behavior from a broad viewpoint. Systems models designed for simulation by analog and digital methods. Special topics such as hybrid computation included.

I.Sy.E. 3749. Elementary Quality Control

3-0-3. Not available to I.Sy.E. students or students with credit for I.Sy.E. 4039.

Introduction to industrial quality control using statistical methods. Includes methods of data analysis, sampling and control charts as applied to manufacturing processes.

I.Sy.E. 4000. Introduction to Systems Theory

3-0-3. Prerequisite: consent of department.

The basic, classical and modern concepts and tools required for modeling, analysis and synthesis of linear, discrete and continuous, deterministic and dynamic systems.

I.Sy.E. 4005. Nonlinear Programming

3-0-3. Prerequisite: I.Sy.E. 3033 or equivalent.

Solution procedures for nonlinear programs. Unconstrained optimization, gradient and gradient-free methods, constrained optimization, Lagrange multipliers, penalty functions and linear approximation methods.

I.Sy.E. 4006. Integer and Dynamic Programming

3-0-3. Prerequisite: I.Sy.E. 3033 or equivalent.

Optimization by dynamic and integer programming. Decision trees, optimality principle and recursive relationships. Optimization in integer by cutting planes, branch and bound and implicit enumeration.

I.Sy.E. 4007. Applications of Network Flow Theory

3-0-3. Prerequisites: I.Sy.E. 3033 or equivalent.

Uses of graph and network theory in modeling and solving transportation, assignment, location, scheduling, distribution and traveling salesman type problems.

I.Sy.E. 4010. Systems Analysis I
4-0-4. Prerequisite: I.Sy.E. 3080, Math. 2309 or equivalent.

Analysis of linear deterministic systems emphasizing matrix theory and the state variable sets of ordinary differential equations for systems representations.

I.Sy.E. 4011. Systems Analysis II
4-0-4. Prerequisite: I.Sy.E. 3080, 3027 or equivalent.

Analysis of linear stochastic systems emphasizing statistical descriptions of random processes and the response of linear systems to stationary random input processes.

I.Sy.E. 4022. Job Evaluation and Wage Incentives
3-0-3. Prerequisite: I.Sy.E. 3010.

Study of principles used to establish wage rates and salaries. Emphasizes characteristics and objectives of wage incentive plans and design and analysis of incentive formulas.

I.Sy.E. 4024. Fundamentals of Materials Handling
2-3-3. Prerequisite: I.Sy.E. 3010, 3025.

Development of procedures and techniques for analysis and solution of materials handling problems. Plant trips and laboratories utilized to illustrate modern materials handling methods.

I.Sy.E. 4028. Introduction to Feedback Dynamics
2-3-3.

Examination of feedback processes as causes of dynamic behavior in socio-economic and managerial systems. Emphasizes feedback loop performance characteristics and computer simulation of multivariate non-linear systems.

I.Sy.E. 4033. Electronic Data Processing

3-0-3. Prerequisite: senior standing or consent of department.

Survey of electronic data processing including important applications, characteristics of data processing equipment, programming systems and methodology for analysis and design of management information systems.

I.Sy.E. 4035. Project Management Systems Design

2-3-3. Prerequisite: senior standing or consent of department.

Project planning and control using activity network analysis. Emphasizes network logic, scheduling computations, resource scheduling, time-cost tradeoff algorithms and multiproject resource allocation.

I.Sy.E. 4036. Elements of Safety Engineering

3-0-3. Prerequisite: I.Sy.E. 3010, 3027. Not available to students with credit for I.Sy.E. 4037.

Nature and extent of industrial accident problems including identification and solution of technical accident problems using engineering design and analysis techniques for accident prevention.

I.Sy.E. 4037. Industrial Safety Administration

3-0-3. Prerequisite: senior standing or consent of department. Not available to students with credit for I.Sy.E. 4036.

Control of industrial accidents by non-technical measures. Emphasizes modern organizational relationships in developing safety programs including accident control measurement systems, cost-oriented decision-making.

I.Sy.E. 4038. Industrial Fire Prevention and Protection

3-0-3. Prerequisite: senior standing or consent of department.

Economics of industrial fire risks. Emphasizes design of fire protection facilities and reduction of fire hazards in plants, processes and individual work centers.

I.Sy.E. 4039. Quality Control

3-0-3. Prerequisite: I.Sy.E. 3028 or equivalent. Not available to students with credit for I.Sy.E. 3749.

Design of quality control systems. Quantitative techniques for establishing product specifications, process controls, acceptance inspection and other techniques of quality assurance.

I.Sy.E. 4040. Case Problems in Industrial Engineering

3-0-3. Prerequisite: senior standing or consent of department.

Unstructured diverse problems requiring industrial engineering and systems methodology for pragmatic solutions. Problems simulate challenges most likely to be experienced by functioning professional engineers.

I.Sy.E. 4041. Sales Engineering

3-0-3. Prerequisite: senior standing or consent of department. Available to engineering students only.

Introduction to problems involved in selling technical goods and services requiring engineering skill and knowledge in the design, application, installation and servicing of such products.

I.Sy.E. 4044. Simulation

2-3-3. Prerequisite: I.Sy.E. 3033, 3028.

Simulation methodologies including random generation, time-

keeping and statistical consideration used to solve discrete unit flow systems and sequencing problems. Simulation languages enabling model building and computer solution required.

I.Sy.E. 4048. Systems Design Methodology

3-0-3. Corequisite: I.Sy.E. 3025.

Emphasizes procedural, systematic, analytical and creative approaches to a spectrum of pragmatic problems developing the student's system design capability and appreciation for alternative operable solutions.

I.Sy.E. 4051. Design I

2-6-4. Prerequisite: I.Sy.E. 4048. Prior faculty topic approval required.

Senior group design project requiring system definition, analysis, synthesis, specification and installation of design. Problem areas chosen from research and professional interests of involved faculty and students.

I.Sy.E. 4052. Design II

2-6-4. Prerequisite: I.Sy.E. 4051.

Continuation of I.Sy.E. 4051 with same design group personnel. Project conclusion requires presentations for formal reporting of results to the external sponsoring organization.

I.Sy.E. 4053. Introduction to Socio-Economic System Analysis

3-0-3. Prerequisite: senior standing or consent of department.

Applications of operations research/systems analysis technology and methodology to current social problems. Topics include human resources development, transportation systems, environmental quality and management of municipalities.

I.Sy.E. 4054. Projects I

0-12-4. Prerequisite: senior standing or consent of department. Available to B.E.E.S. degree candidates only. Prior faculty approval required.

Senior group project intended as an integrative experience for students dealing with socio-economic problems related to the B.E.E.S. students' area of major selection.

I.Sy.E. 4055. Project II

0-12-4. Prerequisite: I.Sy.E. 4054.

Continuation of I.Sy.E. 4054 with same project group personnel. Project conclusion requires pilot implementation of project results and recommendations to external sponsoring environment.

I.Sy.E. 4056. Technological Forecasting

3-0-3. Prerequisite: senior standing or consent of department.

Emphasizes forecasting future trends and specific developments in areas of technology. Develops methodologies for identifying future functional capabilities and needs. Case histories in technological forecasting utilized.

I.Sy.E. 4061. Case Studies in Systems Engineering I

2-6-4. Prerequisite: I.Sy.E. 4048, 3080.

Senior group design project for students interested in complex interdisciplinary preliminary systems design. Background lectures and case studies emphasize trade-offs between sub-systems of interest.

I.Sy.E. 4062. Case Studies in Systems Engineering II

2-6-4. Prerequisite: I.Sy.E. 4061, 3081.

Continuation of I.Sy.E. 4061 with same design group personnel.

Project conclusion requires presentations and publication of final report to the external sponsoring systems-oriented organization.

I.Sy.E. 4070. Fundamentals of Operations and Facilities Systems Design

3-3-4. Prerequisite: I.Sy.E. 3010.

Fundamental design procedures and techniques used to create a product or service oriented economic enterprise. Emphasizes organization, methods, materials flow and performance design of the enterprise.

I.Sy.E. 4071. Operations and Facilities Systems Design I

2-6-4. Prerequisite: I.Sy.E. 4048, 4070.

Senior group design project for students interested in operations and facility design in economic enterprises. Background lectures assist groups to develop feasibility study of project environment.

I.Sy.E. 4072. Operations and Facilities Design II

2-6-4. Prerequisite: I.Sy.E. 4071.

Continuation of I.Sy.E. 4071 with same design group personnel. Project conclusion requires final design documents, economic evaluation and presentation to the external sponsoring economic enterprise.

I.Sy.E. 4073. Storage and Distribution Systems Design

3-0-3. Prerequisite: I.Sy.E. 4070.

Fundamentals of designing efficient materials and product distribution systems emphasizing warehouse planning, materials and information flow, equipment selection, building design and location, automated warehousing and transportation.

I.Sy.E. 4074. Facilities Management

3-0-3. Prerequisite: I.Sy.E. 4070.

Study of functions, activities, procedures and organizational interrelationships involved in managing physical facilities, emphasizing maintenance, construction and modification, security and safety, waste disposal and planning.

I.Sy.E. 4075. Engineering the Manufacturing Environment

3-0-3. Prerequisite: I.Sy.E. 4070.

Procedures and methods for designing the enterprise environment emphasizing building design concepts, construction methods, environmental systems, plant services, noise and pollution control and their cost factors.

I.Sy.E. 4080. Analysis of Production/ Inventory Systems

3-3-4. Prerequisite: I.Sy.E. 3033, 3027.

Analytical methods of production/inventory control emphasizing forecasting techniques, inventory models, application of mathematical programming and network models, sequencing and scheduling techniques and line balancing.

I.Sy.E. 4081. Information and Control Systems Design I

2-6-4. Prerequisite: I.Sy.E. 4048, 4080.

Senior group design project for students interested in management information and control systems design. Background lectures develop competency for design of inventory, quality, manpower and fiscal control systems.

I.Sy.E. 4082. Information and Control Systems Design II

2-6-4. Prerequisite: I.Sy.E. 4081.

Continuation of I.Sy.E. 4081 with

same design group personnel. Project conclusion requires design of integrated information-decision system and presentation to the external sponsoring organization.

I.Sy.E. 4090. Legal and Ethical Phases of Engineering

3-0-3. Prerequisite: senior standing or consent of department.

Introduces the engineer to the ethical, legal and professional attitudes to be encountered in his future working environment. Includes business, patent and copyright law considerations.

I.Sy.E. 4500. Director's Honor Seminar

3-0-3. Prerequisite: senior standing in I.Sy.E. and a cumulative point average of 3.0 or better.

Informal discussion-study course covering topics selected by course participants, intended to provide an intellectual interchange dealing with issues of significance to the profession.

I.Sy.E. 4725. Engineering Economy

3-0-3. Prerequisite: sophomore standing. Not available to I.Sy.E. students or students with credit for I.Sy.E. 4726.

Fundamental principles and basic techniques of economic analysis of engineering projects including economic measures of effectiveness, time value of money, cost estimation, breakeven and replacement analysis.

I.Sy.E. 4726. Engineering Economic Analysis in the Public Sector

3-0-3. Prerequisite: sophomore standing. Not available to I.Sy.E. students or students with credit for I.Sy.E. 4725.

Fundamental principles and

basic techniques of engineering economic analysis with emphasis on public works projects. Includes evaluation of economic impact and methods for financing public works.

I.Sy.E. 4765. Industrial Engineering in Hospitals

3-0-3. Prerequisite: senior standing or consent of department.

Study of hospital management systems and means of improvement by application of industrial engineering principles and techniques. Introduction to health systems and survey of medical terminology. Cross listed as H.S. 4765.

I.Sy.E. 4897-8-9. Special Topics

3-0-3 each. Prerequisite: consent of department.

Courses in special topics of timely interest to the profession conducted by resident or visiting faculty.

I.Sy.E. 4991-2-3. Special Problems

Credit to be arranged. Prerequisite: senior standing in I.Sy.E. and prior faculty topic approval.

A one to three hour credit opportunity to develop initiative and apply fundamental principles by performing semioriginal laboratory or research work in industrial and systems engineering.

I.Sy.E. 4994-5-6. Research and Projects

Credit to be arranged. Prerequisite: senior standing in I.Sy.E. and prior faculty topic approval.

Research or project work in conjunction with faculty investigations, which may result in undergraduate thesis. Limited to six hours for students with less than a 3.0 cumulative point average.

I.Sy.E. 6101. Modern Organizations

3-0-3. Prerequisite: I.Sy.E. 3014 or equivalent with consent of department.

A comprehensive study of the theories of industrial organization with particular emphasis on analyzing, evaluating and integrating organizational activities.

I.Sy.E. 6102. Project Selection Methodology for Research and Engineering

3-0-3. Prerequisite: I.Sy.E. 6734 or equivalent with consent of department.

The processes of idea flow, project selection, resources allocation and evaluation in research and engineering will be analyzed using readings from the current literature.

I.Sy.E. 6103. Organizational Decision Making

3-0-3. Prerequisite: I.Sy.E. 6101, 6734.

A course integrating behavioral findings with mathematical models of the decision process. The major focus is on these processes in organizational settings.

I.Sy.E. 6104. The Operating Characteristics of Industrial Engineering Functions

3-0-3. Prerequisite: consent of department.

The design, measurement, and evaluation of work activity. The design, measurement and evaluation of other aspects of operating activity. Operating efficiency from the control viewpoint.

I.Sy.E. 6107. Management of Improvement

3-0-3.

Concepts of the management of improvement endeavors, strat-

egies and tactics for achieving continual improvement within organizations. Theoretical bases and approaches to encourage innovation are studied.

I.Sy.E. 6212. Design of Industrial Engineering Programs

3-0-3. Prerequisite: consent of the department.

Deals with the development of industrial engineering and proceeds to problems in organizing, planning, operating, evaluating and increasing effectiveness of the industrial engineering function.

I.Sy.E. 6213. The Design of Manufacturing Enterprises

3-0-3. Prerequisite: I.Sy.E. 4070 or equivalent.

Deals with the engineering oriented management aspects in designing a manufacturing enterprise. Covers problems unique to developing a new enterprise.

I.Sy.E. 6216. Advanced Work Measurement

3-0-3. Prerequisite: I.Sy.E. 3015 or equivalent.

The history of human work measurement and an examination of research in this field, systems for labor performance evaluation.

I.Sy.E. 6217. Work Center Design

2-3-3. Prerequisite: consent of department.

Advanced study of methods analysis and synthesis with emphasis upon sub-optimizing the work center and on quantitative techniques.

I.Sy.E. 6218. Work System Design

3-0-3. Prerequisite: I.Sy.E. 6217 or consent of department.

Advanced study of the design of work systems with emphasis on

the human operator and his role in the work system.

I.Sy.E. 6219. Human Factors Engineering

3-0-3.

Application of information on man's capabilities and limitations in the design process. Design problems are used to aid understanding of application of human factors data.

I.Sy.E. 6220. Work Physiology

3-0-3.

An evaluation of the various factors affecting human physical performance in the industrial environment. Topics: anthropometry, biomechanics, energy expenditure, heat stress, fatigue, training, strength.

I.Sy.E. 6221. Man-machine Control Systems

3-0-3. Prerequisite: consent of department.

An introduction to the application of systems theory and methodology to the analysis and design of man-machine control systems.

I.Sy.E. 6222. Ergonomics Seminar

3-0-3. Prerequisite: I.Sy.E. 6219.

Seminar in the human factors area pertinent to the design of work systems. Topics: shift work, sex difference, aging, rest periods and occupational safety and health.

I.Sy.E. 6225. Advanced Engineering Economy

3-0-3. Prerequisite: I.Sy.E. 3025, 3033.

Advanced engineering economy topics, including measuring economic worth, economic optimization under constraints, analysis of economic risk and un-

certainty, foundations of utility theory.

I.Sy.E. 6228. Econometric Models in Engineering Economy

3-0-3. Prerequisite: I.Sy.E. 3025, Math. 2309.

Topics include applications of multivariable production functions, optimum size inputs and outputs, analysis of dynamic fluctuations through the use of transforms.

I.Sy.E. 6301. Quality Control Systems

3-0-3. Prerequisite: I.Sy.E. 4039.

The design of quality control systems for production and service enterprises. Topics include costs of quality, quality control systems design and evaluation of system performance.

I.Sy.E. 6305. Forecasting Systems

3-0-3. Prerequisite: Math. 4241 or equivalent.

Techniques and systems for forecasting time series. Statistical methods for generating short term forecasts, analysis of forecast error and design of forecasting systems.

I.Sy.E. 6306. Inventory Systems

3-0-3. Prerequisite: I.Sy.E. 3027, 3033 or equivalent.

An introductory course in inventory theory. Deterministic lot size models, probabilistic models of continuous and periodic review policies, dynamic models and multiechelon systems.

I.Sy.E. 6307. Scheduling Theory

3-0-3. Prerequisite: I.Sy.E. 6656.

Analysis of sequencing and scheduling activities. Static scheduling problems, dynamic scheduling systems, simulation studies of priority dispatching rules, priority queueing models.

I.Sy.E. 6308. Analysis of Production Operations

3-0-3. Prerequisite: I.Sy.E. 6306, 6669.

Mathematical models for production planning. Applications of mathematical programming, dynamic programming, network theory and heuristic methods to problems of planning production, inventories and capacity.

I.Sy.E. 6400. Design of Experiments

3-0-3. Prerequisite: I.Sy.E. 6739 or equivalent.

Analysis and application of standard experimental designs, including factorials, randomized blocks, latin squares, confounding and fractional replication. Orthogonal polynomials and multiple comparisons are also discussed.

I.Sy.E. 6402. Time Series Analysis

3-0-3. Prerequisite: I.Sy.E. 3029 or equivalent.

Building empirical-stochastic models of the autoregressive moving-average form for stationary and nonstationary phenomena. Topics include identification procedures, parameter estimation, diagnostic checking and model forecasting.

Text: At the level of Box and Jenkins, *Time Series Analysis, Forecasting and Control*.

I.Sy.E. 6405. Response Surfaces I

3-0-3. Prerequisite: I.Sy.E. 6400.

Introduction to response surface methodology. Topics include canonical analysis, steepest ascent, first and second order response surface designs, concepts of rotatable and uniform precision designs.

Text: at the level of Myers, *Response Surface Methodology*.

I.Sy.E. 6406. Response Surfaces II
3-0-3. Prerequisite: 6405.

A continuation of I.Sy.E. 6405. Topics include orthogonal blocking in response surface designs, alternative design criteria, the mixture problems and current research problems.

Text: at the level of Myers, *Response Surface Methodology*.

I.Sy.E. 6407. Theory of Sampling
3-0-3. Prerequisite: I.Sy.E. 3029 or equivalent.

Survey sampling techniques. Topics include simple random and stratified random sampling, ratio estimation, regression techniques, systematic, cluster and multistage sampling and sources of error.

Text: at the level of Cochran, *Sampling Techniques*, second edition.

I.Sy.E. 6427. Applied Statistical Decision Theory

3-0-3. Prerequisite: Math. 4241 or equivalent.

An intermediate-level course in statistical decision theory and its application to problems in operations research, industrial and systems engineering.

Text: at the level of Raifa and Schlaifer, *Applied Statistical Decision Theory*.

I.Sy.E. 6510-1. Safe Design and Utilization of Industrial Facilities
3-0-3 each.

The planning, operation and maintenance of industrial facilities to control accident, fire and health hazards. Special reference is made to occupational health and safety legislation.

I.Sy.E. 6615. Analysis of Distribution Systems

3-0-3. Prerequisite: I.Sy.E. 4044, 4080 or equivalent.

Study of the various types of transportation systems available to enterprises for distributive services. Analysis of distribution alternatives stressed, emphasizing design of economic and control systems encountered.

I.Sy.E. 6524. Material Flow Systems

3-0-3. Prerequisite: I.Sy.E. 4070, 4080 or consent of department.

Methodology useful in analysis and design of in-plant material flow systems and their interfaces with transportation and distribution systems emphasizing quantitative and simulation techniques.

I.Sy.E. 6650. Probabilistic Models in Operations Research

3-0-3. Prerequisite: Math. 4222 or equivalent.

Applications of probability and stochastic processes in operations research. Topics include applications of the Poisson process, birth-and-death process and Markov processes.

I.Sy.E. 6656. Queueing Theory

3-0-3. Prerequisite: Math. 4215 or equivalent.

Topics include a probability review, properties of the Poisson and exponential distributions, one-dimensional and multidimensional birth-and-death queueing models.

Text: at the level of Cooper, *Introduction to Queueing Theory*.

I.Sy.E. 6669. Linear Deterministic Models in Operations Research

4-0-4. Prerequisite: I.Sy.E. 3033 or equivalent.

The optimization of linear models, including the revised, dual, and primaldual simplex methods, duality theorems, decomposition, cutting plane algorithms, some network algorithms.

I.Sy.E. 6670. Nonlinear Deterministic Models in Operations Research

4-0-4. Prerequisite: I.Sy.E. 3033 or equivalent.

Algorithms for solving nonlinear constrained and unconstrained problems at the level of Aoki, *Introduction to Optimization Techniques*. Quadratic programming, dynamic programming and enumerative methods.

I.Sy.E. 6734. Methods of Operations Research

5-0-5. Prerequisite: Math. 2309. Corequisite: statistics.

An introduction to the methods for the analytical formulation and solution of decision problems. Mathematical methods of optimization and classical operations research models are introduced. Not available for degree credit to I.Sy.E. students.

I.Sy.E. 6739. Experimental Statistics

4-0-4. Prerequisite: Math. 2308.

An introduction to the application of statistics. Topics include probability concepts, sampling distributions, point and interval estimation, hypothesis testing, multiple linear regression, analysis of variance.

Text: at the level of Hines and Montgomery, *Probability and Statistics*.

I.Sy.E. 6751-2. Complex Systems Design

2-4-3 each. Prerequisite: graduate standing.

This two-quarter sequence permits students from all schools to meet, form an interdisciplinary team and carry out preliminary design of a significant, complex system.

I.Sy.E. 6765. Analysis of Health Care Delivery Systems

3-0-3. Prerequisite: I.Sy.E. 4765, 6734 or consent of department.

Survey of management and research problems occurring in health-care delivery complexes together with critical analysis of technical studies employing operations research and systems engineering methodologies. Cross listed as H.S. 6765.

I.Sy.E. 6800. Systems Research and Application I

3-0-3. Prerequisite: I.Sy.E. 4000 or consent of department.

Individual work and study of cases reflecting the application of the systems engineering process to the modeling, analysis, design and implementation of various classes of man-machine, socio-economic and ecological systems.

I.Sy.E. 6801. Systems Research and Applications II

3-0-3. Prerequisite: I.Sy.E. 6800.

An interdisciplinary class project requiring small team organization, and directed at the application of the systems engineering process to a single problem area.

I.Sy.E. 6802-3. Advanced Systems Theory I and II

3-0-3 each. Prerequisite: I.Sy.E. 4000.

A course extending linear, continuous, deterministic methodologies to nonlinear, discrete and stochastic dynamic system representations and analysis.

I.Sy.E. 6805. Reliability Engineering

3-0-3. Prerequisite: Math. 4215, 4221 or equivalent.

Reliability prediction for non-maintained systems, availability

prediction for maintained systems, life demonstration test design, the concept of system effectiveness.

I.Sy.E. 6806. Introduction to Feedback Dynamics

3-0-3.

Philosophy of feedback causality. Methodology for formulation, analysis and synthesis of feedback models and real implementation. Emphasis on large social systems with intangible variables. Student project.

I.Sy.E. 6807. Feedback Dynamics Principles

3-0-3. Prerequisite: I.Sy.E. 6806.

Detailed model building. Simulation by hand and DYNAMO. Study of oscillation, growth, frequency sensitivity, phasing, noise in feedback models. Model trouble-shooting and improvement. Student project.

I.Sy.E. 6808. Feedback Dynamics Applications

3-0-3. I.Sy.E. 6806, 6807 suggested, but not required.

Design/modification of human organizations. Extensive student project illustrates principles presented in I.Sy.E. 6806-7 and provides exercise in creative real-system synthesis and recommendation implementation.

I.Sy.E. 6830. Simulation Techniques

1-6-3. Prerequisite: I.Sy.E. 4044. Corequisite: I.Sy.E. 6400.

Random generators, process generators, timekeeping, variance reduction. Recent research in simulation. The design, test and evaluation of a nontrivial simulation model.

I.Sy.E. 7000. Master's Thesis

Required of degree candidates.

I.Sy.E. 7441. Linear Statistical Models I

3-0-3. Prerequisite: Math. 4241 and I.Sy.E. 6400.

Introduction to full rank linear statistical models, including least squares and maximum likelihood estimation, interval estimation and hypothesis testing. Regression models are discussed.

Text: at the level of Grayhill, *Linear Statistical Models*.

I.Sy.E. 7442. Linear Statistical Models II

3-0-3. Prerequisite: I.Sy.E. 7441.

A continuation of I.Sy.E. 7441 emphasizing linear statistical models of less than full rank. Balanced designs, including fixed, mixed and random models are stressed.

Text: at the level of Graybill, *Linear Statistical Models*.

I.Sy.E. 7656. Advanced Queueing Theory

3-0-3. Prerequisite: I.Sy.E. 6656.

For those interested in advanced work and research. Topics include imbedded Markov chain queueing models, waiting times under various queue disciplines, and current research problems.

Text: at the level of Cooper, *Introduction to Queueing Theory*.

I.Sy.E. 7671. Foundations of Optimization

3-0-3. Prerequisite: Math. 4311.

Conditions for optimality and nonlinear duality generalized to nonconvex functions, and its use in nonlinear programming.

Text: at the level of Mangasarian, *Nonlinear Programming*.

I.Sy.E. 7672. Optimization: Adjacent Extreme Point Methods

3-0-3. Prerequisite: I.Sy.E. 6669.

A study of current literature in adjacent extreme point methods

including quasi-concavity, recent duality results, complementary pivot theory, quadratic and stochastic programming.

I.Sy.E. 7673. Nonlinear Programming

3-0-3. Prerequisite: I.Sy.E. 6670.

Nonlinear programming algorithms with emphasis on strategy and convergence at the level of Zangwill, *Nonlinear Programming*. Derivative and derivative-free methods, Lagrange multipliers, penalty functions, conjugate directions, feasible directions and cutting planes.

I.Sy.E. 7674. Dynamic Programming I

3-0-3. Prerequisite: I.Sy.E. 6669 or equivalent.

Advanced treatment of the elements of modern dynamic programming via the state space formalism. Problem formulation, computational aspects and dimensionality reduction. Application to various fields.

I.Sy.E. 7675. Network Flows

3-0-3. Prerequisite: I.Sy.E. 6669.

Current literature in networks including characterization theorems and algorithms for flow problems, flow with gains, multicommodity flows, disconnecting sets and matching theory.

I.Sy.E. 7677. Integer Programming

3-0-3. Prerequisite: I.Sy.E. 6669.

The methods and applications of integer programming including cutting plane methods, implicit enumeration, heuristic techniques, group theoretic and other developments.

I.Sy.E. 7678. Decomposition Methods for Large Systems

3-0-3. Prerequisite: I.Sy.E. 6669.

Solution strategies, illustrated

with examples, for handling complex systems with large number of variables and/or restrictions, linear and nonlinear.

I.Sy.E. 7765. Projects in Health Care Delivery Systems

1-6-3. Prerequisite: I.Sy.E. 6765 or consent of department.

Research projects addressed at real-life problems confronting operational health care institutions and employing modern principles and approaches of health systems analysis. Project report. Cross listed as H.S. 7765.

I.Sy.E. 8001-2-3. Seminar

1-0-0 each.

I.Sy.E. 8061-2-3. Seminar in Operations Research

Credit to be arranged. Prerequisite: consent of department.

Topics within the area of operations research of a special interest to the faculty and graduate students, and which are not included in regularly offered courses.

I.Sy.E. 8081-2-3. Seminar in Systems Engineering

Credit to be arranged. Prerequisite: I.Sy.E. 6801.

Specific systems will be selected for detailed and in depth data collection, simulation and analysis utilizing the theory provided in the systems research and application courses.

I.Sy.E. 8100-1-2. Special Topics

3-0-3 each. Prerequisite: consent of department.

Special topic offerings not included in regular courses.

I.Sy.E. 8120-1-2. Topics in Safety Engineering

3-0-3 each. Prerequisite: consent of department.

This course will be devoted to

special topic offerings in the field of safety engineering.

I.Sy.E. 8601-2. Projects in Operations Research

Credit to be arranged. Prerequisite: consent of department.

This course provides, through project work, experience in the application of operations research methods to real world systems. operations research methods to real world systems.

I.Sy.E. 8704-5-6. Special Problems in Industrial Engineering

Credit to be arranged. Prerequisite: consent of department.

I.Sy.E. 9000. Doctoral Thesis

Information and Computer Science

Note: the four-digit course numbering system of the School of Information and Computer Science has several mnemonic features. The first digit indicates the course level (1xxx - 4xxx undergraduate, 6xxx - 9xxx graduate). The second digit designates the subject orientation of the course: theory and foundations (x1xx), professional milieu (x2xx), computing applications (x3xx), computer software (x4xx), numeric computing and mathematics (x5xx), computer hardware and systems (x6xx), service courses (x7xx), and special problems (x8xx). The last three digits in the range x200 through x699 are identical with the subject codes of *Computing Reviews*, thus facilitating the student's access to the current literature related to these courses.

I.C.S. 1100. Information, Computers and Systems: an Introduction

2-3-3.

An orientation to the discipline and professions of information, computer and systems science and to their functions in science and society.

I.C.S. 1110. Reasoning and Computation

3-0-3.

Elementary survey of the function of signs in thought and action, problem recognition, beliefs, language, meaning, information, inference, formalization, logic, programs and computation.

I.C.S. 1400. Introduction to Algorithms and Computing

2-3-3.

First course on problem solving using computers. The concept, properties and notation of algorithms. Problem analysis, development of algorithms and their implementation in BASIC.

I.C.S. 1700. Digital Computer Organization and Programming

2-3-3.

Algorithmic processes of problem solving, properties of algorithms, development of algorithms for the solution of numerical and non-numerical problems. The FORTRAN programming language. No credit for I.C.S. majors.

I.C.S. 2250. Technical Information Resources

1-0-1.

Introduction to the literature and information services of science, engineering and management. Effective uses of the Georgia Tech library.

I.C.S. 2400. Computer Programming

2-3-3. Prerequisite: I.C.S. 1400.

In-depth, parallel description of the syntax and semantics of FORTRAN and ALGOL and their effective use in the solution of problems.

I.C.S. 2600. Computer Organization and Programming

3-0-3. Prerequisite: I.C.S. 2400.

Introduction to computer organization, machine-language programming and assembly systems. Internal data structures, selected programming techniques.

I.C.S. 2700. Computer and Programming Systems

3-0-3. Prerequisite: I.C.S. 1700 or equivalent.

Introduction to digital computer systems, computer organization, assembly language programming and the structuring and processing of information. No credit for I.C.S. majors.

I.C.S. 3110. Semiotics

3-0-3.

Basic concepts of signs relevant to natural and artificial sign processing systems. The representation relation, classification of signs. Analysis of sign systems. Examples and exercises.

I.C.S. 3113. Information Structures and Processes

3-0-3. Prerequisite: I.C.S. 2600 or 2700.

Logical data structures and their machine representation. Processes on data structures, including scanning, searching and sorting, with emphasis on list processing techniques.

I.C.S. 3116. Philosophy of Grammar

3-0-3. Prerequisite: junior standing.

Study of the philosophical foundations of prominent linguistic theories in history. Emphasis is on Indian, Greek, Latin, medieval and rationalistic contributions to language theory.

I.C.S. 3146. Introduction to Cybernetics

3-0-3.

History and branches of cybernetics. Concepts of system, structure, behavior, modeling, information, communication, self-organization and control are treated with respect to natural and artificial systems.

I.C.S. 3150. Introduction to Mathematical Logic

3-0-3. Prerequisite: Math. 2020.

Introduction to formal systems for the logical appraisal of inferences, including quantification and identity theory, referential interpretation, first order languages, soundness and completeness.

I.C.S. 3151. Proof Theory

3-0-3. Prerequisite: I.C.S. 3150.

Introduction to various facets of modern proof theory, including mechanical theorem proving and its application in computer science.

I.C.S. 3342. Introduction to Computational Linguistics

3-0-3. Prerequisite: I.C.S. 3113, Ling. 4002.

Approaches to natural language processing by computer. Concordance construction, syntactic analysis, question-answering systems, mechanical translation and computer programs for linguistic research.

I.C.S. 3400. Automatic Data Processing

2-3-3. Prerequisite: I.C.S. 1700 or 2400.

Development of algorithms for the solution of business-oriented problems. File structure organization and processing on different types of storage devices. The COBOL programming language.

I.C.S. 3422. Survey of Programming Languages

3-0-3. Prerequisite: I.C.S. 2600 or 2700.

Contrastive description of the linguistic constructs and implementation characteristics of widely used, representative programming languages such as ALGOL, FORTRAN, COBOL, SNOBOL 4, LISP, PL/I and APL.

I.C.S. 3510. Computer-Oriented Numerical Methods

2-3-3. Prerequisites: I.C.S. 1700 or 2400, Math. 1309.

Introduction to computer oriented numerical methods for error analysis, function evaluation, solution of systems of equations, curve-fitting, interpolation, numerical integration and differentiation.

I.C.S. 3600. Computer Systems I

3-0-3. Prerequisite: I.C.S. 3113.

Basic hardware and software components of computer systems. Topics include input/output, interrupts, storage devices, elements of operating systems, and microprogramming.

I.C.S. 3601. Computer Systems II

3-0-3. Prerequisite: I.C.S. 3600, Math. 3215 or equivalent.

Study of hardware and software components of multiprogrammed computer systems including system architecture, virtual

memory, segmentation and paging and parallel processing.

I.C.S. 4110. Topics in Linguistics

3-0-3.

Study of selected topics in the grammar and semantics of natural language. The course is intended for graduate students with no prior background in linguistics.

I.C.S. 4112. Formal Semantics

3-0-3. Prerequisite: I.C.S. 3150.

Introduction to the relationship between formal languages and their possible interpretations, the latter being treated as abstract mathematical structures.

I.C.S. 4117. Introduction to Mathematical Linguistics

3-0-3. Prerequisite: I.C.S. 3150, Math. 3215, Ling. 4002.

Application of statistical and algebraic approaches to the study of linguistic structures from the viewpoint of their utility to a wide range of problems.

I.C.S. 4120. Introduction to Information Processes I

3-0-3. Prerequisite: I.C.S. 1110, Math. 3215.

Explication of the information concept, its properties, information processes, content analysis and control, information sources, information transmission, channel capacity and efficiency, coding, noisy communication channels.

I.C.S. 4121. Introduction to Information Processes II

3-0-3. Prerequisite: I.C.S. 4120.

Perception, cognition, classification, data structures, choice of measurements, classification and clustering techniques, classification schemata in documentation, indexing, evaluation of classification and indexing. Pattern recognition.

I.C.S. 4136. Problem Solving

3-0-3. Prerequisite: I.C.S. 3150.

General approaches to problem solving, with emphasis on methods and techniques of formalizing intuitive heuristics. Structure of problems and goals, generation of alternatives. Incomplete information.

I.C.S. 4150. Logistics Systems

3-0-3. Prerequisite: I.C.S. 3150.

An intermediate-level course dealing with formal systems for the logical appraisal of inferences. Introduction to the logic of programs.

I.C.S. 4153. Computing Languages

3-0-3. Prerequisite: I.C.S. 3150, 3422.

Introduction to the formal study of programming languages, including language construction based on Markov algorithms, complex languages features, data structures, embedding and extensibility.

I.C.S. 4156. Theory of Abstract Machines

3-0-3. Prerequisite: Math. 2020.

Study of fundamental concepts in the formal theory of automata emphasizing finite state machines, Turing machines and computational power of machines.

I.C.S. 4157. Theory of Computability

3-0-3. Prerequisite: I.C.S. 3150, 4156.

Introduction to formalizations of the notion of effective computability, with application to logic and automata. Turing computable and recursive functions, Godel's theorems.

I.C.S. 4250. Literature of Science and Engineering

2-3-3.

Study of the reference and bibliographic sources of scientific, engineering and management literature, emphasizing strategies of manual and computer searching. Bibliographic project in student's discipline.

I.C.S. 4300. Information Systems

3-0-3. Prerequisite: I.C.S. 1700 or 2400.

Major categories of information systems. Empirical methodology of analysis and design of computer-based systems. Definition of objectives, planning, analysis, design, implementation, evaluation. Case studies.

I.C.S. 4305. Science Information Systems

3-0-3. Prerequisite: I.C.S. 4300.

Information and communication in science. Design of science data banks, document repositories, information transfer services. Science information control at national and international levels.

I.C.S. 4334. Health Information Processing

3-0-3. Prerequisite: I.C.S. 4300.

Information processing applications in health care and biomedical research. Patient records, automation of clinical laboratory, hospital information systems, diagnostic decision making, biomedical documentation.

I.C.S. 4350. Data Management Systems

3-0-3. Prerequisite: I.C.S. 3422. Prerequisite or corequisite: I.C.S. 3601.

Introduction to logical and physical structures of computer data bases. Topics include file

organization, directory decoding, searching, maintenance. Data Base Task Group Report.

I.C.S. 4360. Artificial Intelligence and Heuristics

3-0-3. Prerequisite: I.C.S. 3150, 3601.

Heuristic vs. algorithmic methods for automatic problem solving. Study of machines and programs that deduce answers to questions from given facts, play games, prove theorems.

I.C.S. 4370. Information Storage and Retrieval

3-0-3. Prerequisite: I.C.S. 3113, Math. 3215, Ling. 3003.

Computer-aided organization and retrieval of bibliographic and natural-language information. Topics include statistical, syntactic and logical analysis of information content, evaluation of retrieval effectiveness.

I.C.S. 4380. Data Communications

3-0-3. Prerequisite: I.C.S. 3601.

Comprehensive introduction to computer telecommunications, including data codes, communication media, terminal devices and associated software, common carrier services, system design, cost analysis, telecommunications policy.

I.C.S. 4390 Computer Graphics

3-0-3. Prerequisite: I.C.S. 3113.

Introduction to computer graphics: underlying principles, devices, systems and applications. Hands-on experience with available hardware and software packages. Programming projects in computer graphics.

I.C.S. 4410. Introduction to Compilers

3-0-3. Prerequisite or corequisite: I.C.S. 3601.

Study of techniques for compiling the basic constructs of computer languages: arithmetic and Boolean expressions, iterative and conditional constructs, sub-program capability.

I.C.S. 4430. Introduction to Operating Systems

3-0-3. Prerequisite: I.C.S. 3601.

Survey of operating systems concepts, including interrupt-driven systems, internal queues, memory and processor allocation, files, input-output, batch and remote, system accounting, instrumentation.

I.C.S. 4500. Mathematical Techniques for Information Science

3-0-3. Prerequisite: consent of department.

Mathematical topics of relevance in information, computer and systems science which are not explicitly included in the required core programs of the school.

I.C.S. 4560. Elements of Information Theory

3-0-3. Prerequisite: Math. 3215.

Shannon's mathematical theory of communication, concerning efficient transmission of information through noiseless and noisy channels, including proof of Shannon's fundamental theorem for discrete memoryless channels.

I.C.S. 4600. Computer Systems Laboratory

2-12-6. Prerequisite: I.C.S. 3601.

Intensive, hands-on computer laboratory for I.C.S. majors. Machine-level operations, programming, computer interfacing.

I.C.S. 4610. Logic Design and Switching Theory

3-0-3. Prerequisite: I.C.S. 3150.

Theory and design of computer logic. Boolean algebra AND/OR, NAND, NOR elements, maps, combinatorial circuits, sequential circuits, logic spaces, systems of simultaneous Boolean equations.

I.C.S. 4611 Computer Systems

1-6-3. Prerequisite: I.C.S. 4610.

Laboratory component of I.C.S. 4610. Logical design of digital computers, construction and testing of prototype devices.

I.C.S. 4800. Selected Topics in Information and Computer Science

3-0-3. Prerequisite: permission of department.

Seminar designed to permit selected groups of students to pursue further study of significant areas of information, computer and systems science.

I.C.S. 4810-1-2. Design Project I, II, III

0-6-2 each. Prerequisite: permission of department.

An undergraduate thesis sequence consisting of an analytical or empirical investigation in an approved area of information, computer and systems science.

I.C.S. 6112. Advanced Semiotics

3-0-3. Prerequisite: I.C.S. 4112.

The semantics of higher order languages and various systems of non-standard logic. Topics include many-valued logics, intuitionistic logics, modal logics and logics for programming languages.

I.C.S. 6114. Information Measures

3-0-3. Prerequisite: I.C.S. 3150, Math. 3215.

Theory of quantitative methods of information measurement. Measure functions, syntactic, semantic and pragmatic levels of information measurement,

applications in communication systems, decision making, economic realms.

I.C.S. 6116. Advanced Topics in Linguistics

3-0-3. Prerequisite: I.C.S. 4110 or Ling. 4002.

Study of natural language as a semiotic system with emphasis on a model of grammar incorporating the syntactic, semantic and pragmatic dimensions of semiosis.

I.C.S. 6117. Mathematical Linguistic

3-0-3. Prerequisite: Math. 3215, 4120, I.C.S. 4117.

Study of the mathematical structure of natural language using statistical and algebraic techniques.

I.C.S. 6130. Philosophy of Mind

3-0-3. Prerequisite: graduate standing.

Higher mental processes including learning, concept formation, problem solving and perception, considered in relation to artificial intelligence. Linguistic and physiological models of human information processes.

I.C.S. 6135. Theory of Communication

3-0-3. Prerequisite: I.C.S. 6130.

Man-machine communication is analyzed by reference to studies of behavioral decision, conversational systems and interactive measurement methods.

I.C.S. 6140. Systems Theory I

3-0-3. Prerequisite: Math. 2020.

Discrete dynamical processes, state variable characterization, classification. Autonomous processes, open and closed subprocesses and interaction. Algorithmic processes. Switching

circuits, sequential machines, memory and delay. Linearity.

I.C.S. 6141. Systems Theory II

3-0-3. Prerequisite: I.C.S. 6140.

Discrete dynamical processes, recurrence equations and difference equations. Stability and convergence. Linearity, realizations, controllability and observability, response separation and transfer functions. Sensitivity, control and optimization.

I.C.S. 6144-5. Information Systems Design I, II

3-0-3 each. Prerequisite: I.C.S. 4300.

Analysis and synthesis of information systems, emphasizing mathematical modeling. Study of selected systems in areas such as data processing, management, command and control systems.

I.C.S. 6146. Cybernetics

3-0-3.

Roles of various functions in living systems and their actual or potential realization in computers.

I.C.S. 6147. Theory of Models

3-0-3. Prerequisite: Math. 3215, I.C.S. 3600.

Modeling of complex systems especially for digital simulation. Statistical and other methodological considerations. Simulation versus mathematical, numerical and other analysis. Projects in modeling and simulations.

I.C.S. 6152. Theory of Automata

3-0-3. Prerequisite: I.C.S. 4156.

Study of the significant results concerning finite automata, pushdown automata, linear bounded automata, Turing machines, recognizers of the four Chomsky phrase-structure languages.

I.C.S. 6157. Advanced Theory of Computability

3-0-3. Prerequisite: I.C.S. 4157.

Advanced treatment of the theory of computability. Topics include recursive functions, recursively enumerable sets and relations, degrees of unsolvability, the recursion theorem and computational complexity. Various applications to logic and automata theory will also be considered.

I.C.S. 6210. Communication and Control of Information

3-0-3.

Effects of information control on human activities are analyzed at the individual, group and societal levels. Methodological issues are illustrated in the interpretation of empirical studies.

I.C.S. 6240. Organization and Management of Information Industry

3-0-3. Prerequisite: Mgt. 6160.

Principles of organization, operation and management of the information industry, computing services and centers, software companies, information brokers. Vendor relationship. Functions of government, professional associations.

I.C.S. 6300. Advanced Systems Design

3-0-3. Prerequisite: I.C.S. 4300 or equivalent experience.

Study of techniques useful in the empirical design of information systems, emphasizing quantitative methods of systems analysis, modeling, simulation, synthesis and evaluation.

I.C.S. 6301. Problems in Systems Design

0-6-2. Prerequisite: permission of department.

Advanced practicum in the analysis, synthesis, modeling, simulation or evaluation of information processing systems or their components. Small-group or individual student projects.

I.C.S. 6350. Computer Techniques for Information Storage and Retrieval

2-3-3. Prerequisite: I.C.S. 4350.

Study of the state of the art in data base design. Approaches to data base formalisms and standardization. Term project.

I.C.S. 6360. Artificial Intelligence
3-0-3. Prerequisite: I.C.S. 3151, 4360.

Advanced study of topics from heuristic search, automatic theorem proving, semantic information processing, representation theory and robot research.

I.C.S. 6363. Pattern Recognition
3-0-3. Prerequisite: Math. 3215 or equivalent.

Selected topics from statistical pattern recognition. Examination of the problems of extracting useful information from pictures by automatic means.

I.C.S. 6370. Information Control Methods
3-0-3.

Study of methods of information control, including assessment of information needs, data collection and reduction, manual and automatic indexing, abstracting and classification, evaluation and performance.

I.C.S. 6410. Computer Language Design
3-0-3. Prerequisite or corequisite: I.C.S. 3601.

Detailed study of the basic techniques of compiler implemen-

tation, including lexical scan, translation to intermediate language, object code generation and optimization.

I.C.S. 6412. Syntax Directed Compilation

3-0-3. Prerequisite: I.C.S. 6410.

Techniques for automating compiler construction, given appropriate descriptions of the syntax and the desired object code for the language being compiled.

I.C.S. 6430. Computer Operating Systems

3-0-3. Prerequisite: I.C.S. 3601.

Comprehensive study of the structure and implementation of computer operating systems for a spectrum varying from mini-computers to large time-sharing systems.

I.C.S. 6431. Design of Computer Operating Systems

1-6-3. Prerequisite: I.C.S. 6430 or consent of school.

Laboratory project in operating system design. Typically, students design, test and merge independent modules to form the nucleus of an operating system.

I.C.S. 6530. Graph Theory
3-0-3.

Algorithmic combinatorics, including topics in permutations, combinations, enumeration, graphs and trees, with applications in information, computer and systems science.

I.C.S. 6555. Queueing Theory and Applications I

3-0-3. Prerequisite: Math 3215.

Queueing theory and its application in computer performance evaluation, operating systems design, telecommunications and operations research, intended for

students interested in research or advanced applications.

I.C.S. 6556. Queueing Theory and Applications II

3-0-3. Prerequisite: I.C.S. 6555.

Continuation of I.C.S. 6555, emphasizing current research topics. Problems suitable for dissertation research are discussed.

I.C.S. 6620. Advanced Computer Organization

3-0-3. Prerequisite: I.C.S. 4610.

Study of formal transition from a given algorithm to the corresponding hardware structure, its timing, control and optimization.

I.C.S. 6621. Equipment of Information Systems

1-6-3. Prerequisite or corequisite: I.C.S. 6620.

Laboratory component of the professional graduate programs principally related to I.C.S. 6620 and emphasizing the hardware/software interface at the logic level of digital computers.

I.C.S. 7000. Master's Thesis

Credit to be arranged. Prerequisite: consent of school.

I.C.S. 7115. Philosophy of Language

3-0-3. Prerequisite: I.C.S. 6116.

Study of selected topics in linguistics arising from philosophic discussion of language. Emphasis on contributions of Russell, Carnap, Quine and Martin to modern linguistic thought.

I.C.S. 7120-30. Information Processes I, II

3-0-3 each. Prerequisite: consent of school.

Advanced seminars in the theory and formalization of complex semiotic processes (e.g.,

classification, communication, problem solving, decision making), treated from the viewpoint of artificial intelligence.

I.C.S. 7145. Information Systems Optimization

3-0-3. Prerequisite: I.C.S. 6145.

Study of structures and behavior patterns which optimize information systems performance relative to selected efficiency criteria. Applications of queueing theory, network theory and mathematical programming.

I.C.S. 7430. Evaluation of Computer Systems

2-3-3. Prerequisite: I.C.S. 6430, Math. 3215.

Methods of evaluating performance of large-scale computer systems, with emphasis on performance analysis through simulation and queueing models.

I.C.S. 7999. Preparation for Doctoral Qualifying Exams

Credit to be arranged. Prerequisite: consent of school.

I.C.S. 8001-2-3. Seminar

1-0-0 each. Prerequisite: consent of school.

I.C.S. 8101-2-3. Special Topics

3-0-3 each. Prerequisite: consent of school.

I.C.S. 8501-2-3. Special Problems

Credit to be arranged. Prerequisite: consent of school.

Small-group or individual investigation of advanced topics in information, computer and systems science. Guided study and research.

I.C.S. 8999. Doctoral Thesis Preparation

Credit to be arranged. Prerequisite: consent of school.

I.C.S. 9000. Doctoral Thesis

Credit to be arranged. Prerequisite: consent of school.

Mathematics

Math. 1307. Calculus I

5-0-5. Prerequisite: entrance algebra and trigonometry.

Limits, derivatives, derivatives of rational and trigonometric functions, logarithm and exponential functions, applications of derivatives. Credit is allowed for at most one of the courses Math. 1307, 1317, 1712.

Text: at the level of Seeley, *Calculus of One Variable*, second edition.

Math. 1308. Calculus II

5-0-5. Prerequisite: Math. 1307.

Mean value theorem, definite integral, fundamental theorem of calculus, techniques of integration, first order differential equations, vectors and the laws of motion. Credit is allowed for at most one of the courses Math. 1308, 1318, 1713.

Text: at the level of Seeley, *Calculus of One Variable*, second edition.

Math. 1309. Calculus III

5-0-5. Prerequisite: Math. 1308.

Complex numbers, linear differential equations with constant coefficients, Taylor expansion, infinite sequences and series. Credit is not allowed for both Math. 1309 and 1319.

Text: at the level of Seeley, *Calculus of One Variable*, second edition.

Math. 1317-8-9. Honors Calculus I, II, III

5-0-5 each. Prerequisite: invitation of School of Mathematics.

The topics covered parallel

those of Math. 1307-8-9, with a treatment somewhat more intensive and rigorous.

Text: at the level of Seeley, *Calculus of One Variable*.

Math. 1710. College Algebra and Trigonometry

5-0-5. Prerequisite: entrance algebra. No credit toward graduation for engineering or science degrees.

The function concept, exponential, logarithmic and trigonometric functions, theory of equations including trigonometric equations.

Text: at the level of Johnson, Lendsey, Slesnick, Bates, *Algebra and Elementary Functions*.

Math. 1711. Mathematics for Management I

5-0-5. Prerequisite: entrance algebra.

Sets, counting techniques, binomial theorem, finite sequences and series, probability on finite sample spaces, functions, equations and graphs, basic linear algebra. Credit is not allowed for both Math. 1711 and 2010.

Texts: at the level of Baxter and Sloyer, *Calculus with Probability for the Life and Management Sciences* and Tetra, *Basic Linear Algebra*.

Math. 1712. Mathematics for Management II

5-0-5. Prerequisite: Math. 1711 or 2010.

Continuous functions and limits, optimization, exponential functions and logarithms, inverse functions, derivatives, definite and indefinite integrals. Credit is allowed for at most one of the courses Math. 1712, 1307, 1317.

Text: at the level of Baxter and Sloyer, *Calculus with Probability for the Life and Management Sciences*.

Math. 1713. Mathematics for Management III

5-0-5. Prerequisite: Math. 1712 or 1307 and 1308.

Integration techniques, improper integrals and normal density functions, Taylor polynomials and the Poisson process, multivariate calculus. Credit is allowed for at most one of the courses Math. 1713, 1308, 1318.

Text: at the level of Baxter and Sloyer, *Calculus with Probability for the Life and Management Sciences*.

Math. 2010. Finite Mathematics

5-0-5. Prerequisite: Math. 1712 or 1307.

Elements of logic, set theory, probability and linear algebra, with an introduction to convex sets and linear programming. Credit not allowed for both Math. 2010 and 1711.

Text: at the level of Lipschutz, *Theory and Problems of Finite Mathematics*.

Math. 2020. Introduction to Set-Theoretic Concepts

3-0-3. Prerequisite: Math. 1308 or 1713.

Algebra of sets, cartesian products, relations, equivalence relations, functions, sequences, mathematical induction, equipotence of sets, partially ordered sets.

Text: at the level of Ramanujan and Thomas, *Intermediate Analysis*.

Math. 2205. Elementary Statistical Analysis I

3-0-3. Prerequisite: Math. 1308, 1713.

Probability in finite sample spaces, independent trials, random variables and moments, random sampling, statistical estimation

and hypothesis testing, distribution-free tests of association.

Text: at the level of Mendenhall, *Introduction to Probability and Statistics*.

Math. 2206. Elementary Statistical Analysis II

3-0-3. Prerequisite: Math. 2205.

Random variables with continuous distributions, normal distribution and central limit theorem, statistical inference for normal populations, distribution-free methods, elementary regression and correlation.

Text: at the level of Mendenhall, *Introduction to Probability and Statistics*.

Math. 2307. Calculus IV

5-0-5. Prerequisite: Math. 1309.

Linear algebra, vectors in n -space, vector functions and their derivatives. Credit is not allowed for both Math. 2307 and 2317.

Text: at the level of Flanigan and Kazdan, *Calculus Two*.

Math. 2308. Calculus V

5-0-5. Prerequisite: Math. 2307.

Partial differentiation, multiple integrals, vector analysis, line integrals. Credit is not allowed for both Math. 2308 and 2318.

Text: at the level of Flanigan and Kazdan, *Calculus Two*.

Math. 2309. Differential Equations

5-0-5. Prerequisite: Math. 2308.

Linear differential equations and applications in the engineering and the natural sciences, systems of linear differential equations, series solutions, simple nonlinear equations. Credit is not allowed for both Math. 2309 and 3308.

Text: at the level of Spiegel, *Applied Differential Equations*.

Math. 2317-8. Honors Calculus IV, V

5-0-5 each.

A continuation of Math. 1317, 1318, 1319. The coverage parallels that of Math. 2307-8.

Math. 3110. Introduction to Higher Algebra

3-0-3. Prerequisite: Math. 2307 or 1713.

Vector spaces, matrices, systems of linear equations, linear transformations and matrices, change of basis, characteristic roots and vectors, quadratic forms and diagonalization.

Text: at the level of Kolman, *Elementary Linear Algebra*.

Math. 3215. Problems in Probability and Statistics

5-0-5. Prerequisite: Math. 1309 or 1713.

Basic concepts of probability as in Math. 4215, introduction to statistical inference, a problem-oriented course involving mathematical models in various areas of application. Credit is not allowed for both Math. 3215 and 4215.

Text: at the level of Meyer, *Introductory Probability and Statistical Applications*.

Math. 3308. Differential Equations

5-0-5. Prerequisite: Math. 2308.

Differential equations with linear algebra, matrix treatment of linear systems, characteristic roots, exponential matrix function, series method stressing equations of Bessel and Legendre.

Text: at the level of Rabenstein, *Elementary Differential Equations with Linear Algebra*.

Math. 3643. Introduction to Numerical Computation

5-0-5. Prerequisite: Math. 2308, E.E. 1010 or equivalent.

Problem-oriented course covering solution of linear systems and of nonlinear equations, interpolation and approximation, approximate methods of integration, differentiation and solution of ordinary differential equations.

Math 4010. Introduction to Graph Theory and Combinatorial Mathematics

3-0-3. Prerequisite: entrance algebra.

Fundamental concepts, results and applications of graph theory and combinatorics, including trees, circuits, cutsets, incidence and adjacency matrices, planarity, coloring problems and basic combinatorial tools.

Text: at the level of Busacker and Saaty, *Finite Graphs and Networks*.

Math. 4038. Mathematical Logic

3-0-3. Prerequisite: Math. 2308 or 1713.

The propositional and predicate calculi, developed as formal systems of symbol manipulation, with attention to the related decision problems, recursive functions and automata.

Text: at the level of Stoll, *Introduction to Set Theory and Logic*.

Math. 4110. Introduction to Linear Algebra

3-2-4. Prerequisite: Math. 3110.

Vector spaces, linear transformations, decomposition of spaces, various canonical forms, algebras, inner product spaces.

Text: at the level of Halmos, *Finite-Dimensional Vector Spaces*.

Math. 4120. Introduction to Modern Algebra

3-2-4. Prerequisite: Math. 3110 or consent of department.

Basic properties of sets, relations and maps, elementary theory of groups, including homomorphisms, quotient groups, direct products, elementary theory of rings, integral domains, fields.

Text: at the level of Ames, *An Introduction to Abstract Algebra*.

Math. 4130. Rings and Modules

3-0-3. Prerequisite: Math. 4120.

Embeddings, polynomial rings, principal ideal domains, unique factorization, introduction to modules, direct sums, free modules, modules over a principal ideal domain, applications.

Math. 4140. Theory of Groups

3-0-3. Prerequisite: Math. 3110.

An introductory course in group theory suitable for students of mathematics, chemistry and physics.

Text: at the level of Barnes, *Introduction to Abstract Algebra*.

Math. 4215. Introduction to Probability

3-0-3. Prerequisite or corequisite: Math. 2308.

Introduction to probability theory with applications, discrete and non-discrete distributions, moments, laws of large numbers, central limit theorem with applications. Credit is not allowed for both Math. 4215 and 3215.

Text: at the level of Meyer, *Introductory Probability and Statistical Applications*.

Math. 4221. Probability with Applications

3-0-3. Prerequisite: Math. 3215 or 4215.

Continuation of probability theory from Math. 4215 (3215), random walks, probability generating functions, Markov chain processes, central limit theorem.

Text: at the level of Hoel, Port and Stone, *Introduction to Probability Theory and Introduction to Stochastic Processes*.

Math. 4222. Probability with Applications

3-0-3. Prerequisite: Math. 4221.

Prerequisite or corequisite: Math. 3110.

Continuation of Math. 4221. Topics in probability, including random walks and diffusion, branching processes and stochastic processes with continuous time parameter.

Text: at the level of Hoel, Port and Stone, *Introduction to Stochastic Processes*.

Math. 4241. Mathematical Statistics

3-0-3. Prerequisite: Math. 2308 and either 3215 or 4215.

Introduction to the theory of statistical estimation and hypothesis testing. Exact and asymptotic sampling distributions with applications. Brief treatment of Bayesian inference.

Text: at the level of Hoel, Port and Stone, *Introduction to Statistical Theory*.

Math. 4242. Mathematical Statistics

3-0-3. Prerequisite: Math. 4241.

Regression theory, analysis of variance, design of experiments, distribution-free methods of inference.

Text: at the level of Hoel, Port and Stone, *Introduction to Statistical Theory*.

Math. 4280. Elements of Information Theory

3-0-3. Prerequisite: Math. 3215 or 4215.

A mathematical approach to information theory, primarily through

probability in finite sample spaces. Coding theorem for discrete memoryless channels. Decision schemes, Shannon's theorem.

Text: at the level of Ash, *Information Theory*.

Math. 4281. Elementary Decision Theory

3-0-3. Prerequisite: Math. 4241.

Mathematical approach to decision theory, Bayesian and minimax strategies in response to statistical uncertainty, applications to mathematical statistics.

Text: at the level of Ferguson, *Mathematical Statistics: A Decision Theoretic Approach*.

Math. 4282. Introduction to Stochastic Processes

3-0-3. Prerequisite: Math. 4222.

Probabilistic description of continuous parameter stochastic processes, especially Markov, stationary and weakly stationary, normal processes, spectral analysis of time series and ergodic theory.

Text: at the level of Yaglom, *Theory of Stationary, Random Functions*.

Math. 4283. Introduction to Game Theory

3-0-3. Prerequisite: one of Math. 2010, 3110, 4580 or consent of department.

Introduction to game theory with emphasis on zero-sum two-person games, economic applications, connections with linear programming and decision functions.

Text: at the level of Dresher, *Games of Strategy*.

Math. 4308. Ordinary Differential Equations

4-0-4. Prerequisite: Math. 2309 or 3308, Math. 3110 and either 4311 or 4391.

Systems of differential equations, linear systems and phase space analysis, existence theory, stability of linear systems, Liapunov theorems, stability of automatic control systems.

Text: at the level of Brauer and Nohel, *Qualitative Theory of Ordinary Differential Equations*.

Math. 4311. Introduction to Analysis I

3-2-4. Prerequisite: Math. 2309 or 3308 or equivalent.

Real numbers, order completeness, normed vector spaces and notions of completeness and compactness, functions and continuity, sequences and series, differentiation and Riemann integration.

Text: at the level of Bartle, *The Elements of Real Analysis*.

Math. 4312. Introduction to Analysis II

3-2-4. Prerequisite: Math. 4311.

Series of functions, uniform convergence, differentiation of functions from \mathbb{R}^n to \mathbb{R}^m , inverse and implicit function theorems, Lagrange multipliers, curves in \mathbb{R}^n .

Text: at the level of Bartle, *The Elements of Real Analysis*.

Math. 4313. Introduction to Analysis III

3-2-4. Prerequisite: Math. 4312. Prerequisite or corequisite: Math. 4110.

Riemann multiple integrals, improper integrals, line and surface integrals, divergence theorem and theorem of Stokes, introduction to differential forms, change of variables in integrals.

Text: at the level of Bartle, *The Elements of Real Analysis*.

Math. 4320. Complex Analysis

3-0-3. Prerequisite: Math. 2309 or 3308.

Topics from complex function theory, including contour integration and conformal mapping.

Text: at the level of Churchill, *Complex Variables with Applications*.

Math. 4347. Introduction to Partial Differential Equations

3-0-3. Prerequisite: Math. 2309 or 3308.

Second-order linear differential equations, including the wave equation, properties of parabolic and elliptic equations, the method of separation of variables, Fourier series, Green's function.

Text: at the level of Weinberger, *A First Course in Partial Differential Equations*.

Math. 4348. Introduction to Partial Differential Equations

3-0-3. Prerequisite: Math. 4347.

A continuation of Math. 4347. Sturm-Liouville theory and general Fourier expansions, Green's functions, elementary theory of analytic functions of a complex variable.

Text: at the level of Weinberger, *A First Course in Partial Differential Equations*.

Math. 4349. Introduction to Partial Differential Equations

3-0-3. Prerequisite: Math. 4348.

A continuation of Math. 4347, 4348. Applications of complex variables, theory and application of Fourier and Laplace transforms. Approximation methods.

Text: at the level of Weinberger, *A First Course in Partial Differential Equations*.

Math. 4391. Topics from Advanced Calculus I

3-0-3. Prerequisite: Math. 2308.

Partial differentiation, applications of partial differentiation, limits and indeterminate forms, in-

finite series, improper integrals, uniform convergence.

Text: at the level of Widder, *Advanced Calculus*, second edition.

Math. 4392. Topics from Advanced Calculus II

3-0-3. Prerequisite: Math. 4391.

Continuation of Math. 4391. Main topic is integration and applications. Also, Riemann, Stieltjes, multiple, line and surface integrals and the gamma function.

Text: at the level of Widder, *Advanced Calculus*, second edition.

Math. 4431. Introductory Topology

3-0-3. Prerequisite: Math. 4311 or consent of department.

This course provides background for use of topological methods in analysis, metric spaces, continuous transformation, topological spaces.

Text: at the level of Kasriel, *Undergraduate Topology*.

Math. 4432. Introduction to Algebraic Topology

3-0-3. Prerequisite: Math 4431 and 4110 or 4120.

Introduction to algebraic methods in topology. Includes homotopy, the fundamental group, covering spaces, simplicial complexes. Applications to fixed point theory and graph theory.

Math. 4441. Differential Geometry

3-0-3. Prerequisite: Math. 2308.

The theory of curves and surfaces, including the first and second fundamental forms of a surface and topics related to them.

Text: at the level of O'Neil, *Elementary Differential Geometry*.

Math. 4580. Linear Programming

3-0-3. Prerequisite or corequisite: Math. 2308.

Mathematical structure of the

linear programming problem. Requisite topics in linear algebra. Simplex method. Applications.

Text: at the level of Smythe and Johnson, *Introduction to Linear Programming*.

Math. 4581. Advanced Engineering Mathematics

3-0-3. Prerequisite: Math. 2309 or 3308.

The Laplace transform and its properties, applications to physical systems involving the solution of ordinary and partial differential equations.

Text: at the level of Churchill, *Operational Mathematics*.

Math. 4582. Advanced Engineering Mathematics

3-0-3. Prerequisite: Math. 2309 or 3308.

Fourier series, boundary value problems for partial differential equations, applications of Legendre polynomials and Bessel functions.

Text: at the level of Powers, *Boundary Value Problems*.

Math. 4583. Vector Analysis

3-0-3. Prerequisite: Math. 2308.

Vector calculus, line, surface and volume integrals, gradient, divergence, curl, theorems of Green, Gauss and Stokes, curvilinear coordinate systems, introduction to tensors.

Text: at the level of Davis, *Introduction to Vector Analysis*.

Math. 4584. Mathematical Methods in Continuum Mechanics

3-0-3. Prerequisite: Math. 2308.

An elementary tensorial treatment of various geometric and mechanical concepts needed in the study of hydrodynamics, elasticity and plasticity.

Text: at the level of Prager, *In-*

troduction to Mechanics of Continua.

Math. 4591. Introduction to Mathematical Optimization

3-0-3. Prerequisite: Math. 2308.

Introduction to various linear and nonlinear optimization problems in finite-dimensional spaces, mathematical properties of the objective function will be examined and appropriate algorithms developed.

Text: at the level of Cooper and Steinberg, *Introduction to Methods of Optimization*.

Math. 4643. Numerical Analysis I

3-0-3. Prerequisite: Math. 2308.

Numerical solutions of linear and nonlinear equations, interpolation and approximation of functions, finite difference calculus.

Text: at the level of Conte and de Boor, *Elementary Numerical Analysis*, second edition.

Math. 4644. Numerical Analysis II

3-0-3. Prerequisite: Math. 2309 or 3308; or Math. 4643; or consent of department.

Numerical differentiation, numerical integration, difference equations, numerical solution of ordinary differential equations.

Text: at the level of Conte and de Boor, *Elementary Numerical Analysis*, second edition.

Math. 4645. Numerical Analysis III

3-0-3. Prerequisite: Math. 4644 or consent of department.

Numerical approximation of solutions of integral equations and partial differential equations, eigenvalue problems, selected topics of current interest.

Math. 4790. Intensive Review of the Elementary Calculus

10-6-9 audit basis only. Prereq-

quisite: consent of School of Mathematics and student's adviser.

Refresher course for beginning graduate students with calculus background who have been away from academic work for considerable time. Review of calculus through sophomore level.

Math. 4800. Special Topics

3-0-3. Prerequisite: consent of department.

This course enables the School of Mathematics to comply with requests for courses in special topics. Given upon sufficient demand.

Math. 4999. Reading or Research

1 to 3 credits. Prerequisite: junior standing or above, consent of department.

Pass/fail basis only. Not more than seven hours can be counted toward bachelor's degree. At most three hours can be counted as mathematics elective.

Math. 6121. Modern Abstract Algebra I

3-0-3. Prerequisite: Math. 4120.

An introduction to algebraic systems with emphasis on group theory.

Text: at the level of Lang, *Algebra*.

Math. 6122. Modern Abstract Algebra II

3-0-3. Prerequisite: Math. 6121.

Rings, ideals and related concepts, field theory, unique factorization.

Text: at the level of Lang, *Algebra*.

Math. 6123. Modern Abstract Algebra III

3-0-3. Prerequisite: Math. 6122.

Concept of the total matrix

algebra. Introduction to linear associative algebras.

Text: at the level of Lang, *Algebra*.

Math. 6241-2-3. Probability I, II, and III

3-0-3 each. Prerequisite: Math. 6310 or equivalent.

This sequence develops the probability basis requisite in modern statistical theories and stochastic processes. It includes a selection of topics from measure and integration theory, distribution functions, convergence concepts, Fourier integrals and central limit theory, conditional distributions and dependence and random analysis.

Math. 6307-8-9. Ordinary Differential Equations

3-0-3 each. Prerequisite: Math. 3110, 4313.

This sequence develops the qualitative theory for systems of ordinary differential equations. Initial-value problems for systems and n th order equations. Differential inequalities. Stability of linear and perturbed linear systems, Liapunov functions. Boundary-value problems. Periodic solutions and behavior near periodic orbits. Oscillation and comparison theorems. Asymptotic behavior.

Math. 6310. Real Analysis

5-0-5. Prerequisite: Math. 4311, 4312, 4313.

Classes of sets, measures and measurable functions, Lebesgue integration, convergence theorems for integrable functions, absolute continuity, differentiation, L^p spaces, Fourier representations, Fubini's theorem, in \mathbb{R}^n .

Math. 6320. Complex Analysis

5-0-5. Prerequisite: Math. 4311, 4312, 4313, 4320.

Analytic functions, harmonic functions, conformal mapping, Cauchy's theorem, Cauchy's formulas for derivatives, maximum principle, power series, argument principle, residue theory, contour integration, analytic continuation, applications.

Math. 6330. Functional Analysis

5-0-5. Prerequisite: Math. 4110, 4311, 4312, 4313.

Hilbert and Banach spaces, strong and weak convergence, Riesz representation theorem, Hahn-Banach theorem, linear operators, open mapping and closed graph theorems, compact operators, spectral theory.

Math. 6331. Functional Analysis I

3-0-3. Prerequisite: Math. 4311, 4312, 4313, 4120.

Banach and Hilbert spaces, projections on convex sets, Riesz's representation theorem, Hahn-Banach theorems, duality, open mapping and closed graph theorems, uniform boundedness principle.

Text: at the level of Schechter, *Principles of Functional Analysis*.

Math. 6332. Functional Analysis II

3-0-3. Prerequisite: Math. 6331.

Compact operators, unbounded Fredholm operators, closed range theorem. Spectral theory and operational calculus, Banach algebras. Reflexive spaces, weak topologies and extrema. Semigroups.

Text: at the level of Schechter, *Principles of Functional Analysis*.

Math. 6333. Functional Analysis III

3-0-3. Prerequisite: Math. 6332.

Normal and nuclear operators, self-adjoint extensions, square roots, spectral resolutions, bilinear forms, numerical range and dis-

sipative operators. Topics from topological vector spaces, nonlinear functional analysis.

Text: at the level of *Nonlinear Functional Analysis and Application*. Rall, editor.

Math. 6341. Partial Differential Equations I

3-0-3. Prerequisite: Math. 4311, 4312, 4313, 4582.

Classification of partial differential equations, canonical forms, well posed problems, wave equation in R^n , Huygen's principle, potential equation, heat equation, strong maximum principles, fundamental solutions.

Math. 6342. Partial Differential Equations II

3-0-3. Prerequisite: Math. 6341.

Existence theory for elliptic equations, single and double layer potentials, Schwarz alternating procedure, subharmonic functions, weak solutions in a Sobolev space, regularity of weak solutions.

Math. 6343. Partial Differential Equations III

3-0-3. Prerequisite: Math 6342.

Finite dimensional approximation of weak solutions, existence theory for evolution equations, semigroups, fundamental solutions, regularity of solutions, nonlinear evolution equations.

Math. 6431-2-3. General Topology I, II, III

3-0-3 each. Prerequisite: Math. 4431 or consent of school.

Bases and subbases, filters, nets and convergence, continuous functions, separation axioms, connectedness, separability, compactness, sup and weak topologies, products and quotients, compactifications and other embeddings, completeness

and Baire category, uniform spaces, metrization, function spaces, topological groups.

Text: at the level of Wilansky, *Topology for Analysis*.

Math. 6441-2-3. Algebraic Topology I, II, III

3-0-3. Prerequisite: Math. 4431 and 4120 or consent of department.

Introduction to homological algebra, Čech and singular homology and cohomology theories. Applications to fixed points of maps, spheres, invariance of domain, etc., homotopy, the fundamental group, covering spaces. Introduction to sheaf theory, category theory, spectral sequences.

Text: at the level of Spanier, *Algebraic Topology*.

Math. 6510. Deterministic Models from the Physical Sciences and Technology

5-0-5. Prerequisite: Phys. 3121, Math. 4582.

Electrical, mechanical, thermal systems leading to difference equations, lumped parameter electrical, mechanical systems leading to ordinary differential equations, distributed-parameter systems leading to partial differential equations.

Math. 6511. Mathematical Methods of Applied Science I

5-0-5. Prerequisite: Math. 2309 or 3308 and 3110 or consent of department.

The first of three courses providing quick access to mathematical techniques important in science and engineering. Complex variables, linear algebra, linear differential and difference equations.

Math. 6512. Mathematical Methods of Applied Science II

5-0-5. Prerequisite: Math. 6511.

A continuation of Math 6511. Partial differential equations, special functions, operational methods, integral transforms.

Math. 6513. Mathematical Methods of Applied Science III

5-0-5. Prerequisite: Math. 6512 or consent of department.

Approximate methods, nonlinear problems, variational techniques.

Math. 6520. Stochastic Models

5-0-5. Prerequisite: Math. 4222 or 4242, six hours in applied fields at the upper undergraduate level.

Formulation of stochastic models appropriate for solving specific problems of description, prediction and decision, which are posed and analyzed in the context of applied fields.

Math. 6530. Equilibrium and Optimization Models

5-0-5. Prerequisite: six hours in applied fields at the upper undergraduate level, Math. 6330 or concurrently.

Formulation of linear and nonlinear operator models to solve equilibrium or optimal state problems which are posed and analyzed in the context of applied fields.

Math. 6581. Calculus of Variations

3-0-3. Prerequisite: Math. 2309 or 3308 and 3110, 4391, or consent of department.

The calculus of variations, vibration and eigenvalue problems, Sturm-Liouville theory.

Text: at the level of Smith, *Variational Methods in Optimization*.

Math. 6582. Integral Transforms
3-0-3. Prerequisite: Math. 4582, 4320, 4391 or consent of department.

Selected topics from classical transform theory including Fourier, Laplace, Mellin and Hankel transforms, with applications to boundary-value problems.

Text: at the level of Sneddon, *Fourier Transforms*.

Math. 6583. Integral Equations
3-0-3. Prerequisite: Math. 2309 or 3308, and 3110, 4391, or consent of department.

Linear integral equations and corresponding topics in linear algebra.

Text: at the level of Tricomi, *Integral Equations*.

Math. 6584. Special Functions of Higher Mathematics
3-0-3. Prerequisite: Math. 4320, 4391 or consent of department.

Selected functions of particular interest in relation to problems occurring in the physical sciences will be discussed.

Text: at the level of Lebedev, *Special Functions and their Applications*.

Math. 6586. Tensor Analysis
3-0-3. Prerequisite: Math. 3110, 4583, 4391 or consent of department.

Tensor algebra, covariant differentiation, Cartesian tensors, curvilinear coordinates, introduction to differential forms.

Text: at the level of Borisenko and Tarapor, *Vector and Tensor Analysis*.

Math. 6587. Field Theory with Applications
3-0-3. Prerequisite: Math. 4582, 4391 or consent of department.

Solution of field equations of

mathematical physics by Fourier's method in curvilinear coordinate systems. Applications with particular attention to advantageous choice of coordinates.

Math. 7000. Master's Thesis

Math. 7121-2-3. Advanced Topics in Algebra

3-0-3 each. Prerequisite: Math. 6121, 6122, 6123 and consent of department.

Courses directed toward research in algebra. Areas of current research interests include homological algebra, finite groups, semi-groups, loop theory.

Math. 7241-2-3. Studies in Advanced Probability and Statistics
3-0-3 each. Prerequisite: Math. 6241, 6242, 6243 and consent of department.

Courses organized around recent broad advances in probability and statistics basic to research in these fields, content of courses varying from year to year. Typical courses would emphasize stochastic processes, ergodic theory, limit laws of probability, statistical decision theory, theories of estimation and hypothesis testing, etc.

Math. 7307-8-9. Advanced Problems in Ordinary Differential Equations

3-0-3 each. Prerequisite: Math. 6307, 6308, 6309 and consent of department.

Courses directed toward research in differential equations, the content varying from year to year. Representative topics include singular boundary-value problems, asymptotic solutions of differential equations, differential equations containing a large parameter, Poincare-Liapounov

stability theory and differential equations in the large.

Math. 7311-2-3. Advanced Topics in Real Analysis

3-0-3 each. Prerequisite: Math. 6310 and consent of department.

Courses directed toward research in real analysis and related areas, the topics varying from year to year. Topics will be selected from such areas as Hilbert space theory, theory of distributions, abstract harmonic analysis, ergodic theory, Denjoy and Perron integrals.

Math. 7321-2-3. Advanced Problems in Complex Variables

3-0-3 each. Prerequisite: Math. 6320 and consent of department.

Courses directed toward research in complex variables. Representative topics include topics from functions of several complex variables, conformal mapping.

Math. 7431-2-3. Advanced Topics in Topology

3-0-3 each. Prerequisite: consent of department.

The course content will vary from year to year. Topics selected from topological groups, algebraic topology, mapping theory, topological analysis, dimension theory, fixed point theory.

Math. 7501-2-3. Methods of Applied Mathematics

3-0-3. Prerequisite: consent of department.

Topics in a particular year may include some or all of variational techniques, asymptotic methods, differential operators of mathematical physics, Fourier transforms, nonlinear and singular integral equations.

Math. 7643-4-5. Advanced Topics in Numerical Analysis

3-0-3 each. Prerequisite: Math. 4313, 4110 and consent of department.

Discussion of topics of current interest in numerical analysis and related fields with content varying from year to year. Representative topics include matrix iterative analysis, numerical approximations of functions, problems of stability and convergence of difference methods, optimum seeking methods, etc.

Math. 8001-2-3. Seminar

1-0-0 each.

Math. 8100. Special Topics

3-0-3. Prerequisite: consent of department.

This course enables the School of Mathematics to comply with requests for courses in selected topics.

Math. 8504-5-6. Special Problems

Credit to be arranged.

Math. 9000. Doctoral Thesis.

Mechanical Engineering

M.E. 1001. Introduction to Mechanical Engineering

1-0-1. Prerequisite: Math. 1307.

Survey of the field to acquaint the student with the profession, nature, function and working tools, curriculum and topic orientation, engineering in a social context.

M.E. 1110. Creative Decisions and Design

2-3-3.

Basic concepts for creative decisions in engineering problem solving and design. Exposure to practicing engineers, their in-

dustries, problems and accomplishments. Field trips.

M.E. 2212. Materials Science

3-0-3. Prerequisite or corequisite: Math. 2309, Phys. 2123.

Mechanical behavior, elastic and plastic properties, annealing of cold-worked materials leading from atomic concepts, crystallography and relation of crystal defects to properties.

M.E. 3016. Computer Applications
2-3-3. Prerequisite: Math. 2309.

Organization and application of digital and analog computers. Mechanical engineering problems are solved through numerical techniques. Electrical analogs and circuits are used to simulate deterministic systems.

M.E. 3055. Experimental Methodology

1-3-2. Prerequisite: Math. 2309, M.E. 3322.

Presentation of experimental methodology, basic instrumentation used in mechanical engineering and its calibration and use, accuracy, error and uncertainty in experimental measurements, engineering report writing.

M.E. 3113. Mechanisms, Analysis and Synthesis

3-0-3. Prerequisite: E.S.M. 3201.

Analysis and synthesis of the motion of linkages, cams and gears by graphical and analytical methods.

Text: at the level of Shigley, *Kinematic Analysis of Mechanisms*.

M.E. 3114. Dynamics of Machinery
3-0-3. Prerequisite: M.E. 3113, Math. 2309.

Mechanism analysis with emphasis on inertial forces and balancing of rotating and

reciprocating systems. Vibrations of linear systems.

Text: at the level of Phelan, *Dynamics of Machinery*.

M.E. 3183. Rational Descriptions and Engineering Design

3-0-3. Prerequisite: junior standing in engineering.

An elementary treatment of information-theory decision analysis for engineering design with practical applications to the design of mechanical, thermal and electrical components and systems.

M.E. 3212. Materials Technology
3-3-4. Prerequisite: M.E. 2212.

Mechanical and physical properties of metallic and non-metallic materials related to behavior under service conditions. Phase equilibria, microstructure, steels, heat treatment, annealing, fracture, fatigue, creep.

M.E. 3322. Thermodynamics

3-0-3. Prerequisite or corequisite: Phys. 2123, Math. 2308.

An introduction to thermodynamics. Thermodynamic properties, state postulate, work interactions, steady state and transient energy and mass conservations, entropy and the second law.

M.E. 3323. Thermodynamics

3-0-3. Prerequisite: M.E. 3322.

Continuation of M.E. 3322. Applications and corollaries of the second law. Availability, available energy, Carnot theorem, ideal and real gas mixtures, psychrometry, generalized thermodynamic functions.

M.E. 3324. Thermodynamics

3-0-3. Prerequisite: M.E. 3323.

Continuation of M.E. 3323. Gas and vapor power cycles, vapor and gas absorption refrigeration

cycles. First and second law analysis of combustion. Gibbs phase rule, chemical equilibrium.

M.E. 3342. Transport Phenomena I
3-0-3. Prerequisite: Math. 2309.
Prerequisite or corequisite: M.E. 3322.

Introduction to one-dimensional heat, momentum and mass transport, developing rate equations and applying conservation principles, fundamentals of steady and transient heat conduction, including two and three dimensions, sources and extended surfaces, electrical analogies, practical applications.

M.E. 3343. Transport Phenomena II
3-0-3. Prerequisite: M.E. 3342, E.S.M. 2201. Corequisite: M.E. 3323.

Basic conservation concepts in integral form for real fluids, fluid properties and flow characteristics, fluid statics, ideal flows, Euler, Bernoulli and Navier Stokes equations, practical examples.

M.E. 3344. Transport Phenomena III
3-3-4. Prerequisite: M.E. 3343.
Corequisite: M.E. 3324, 3055.

Compressible and incompressible flows, ducted flows, nozzles and shock waves. Radiative transport. Applications.

M.E. 3720. Thermodynamics
4-0-4. Prerequisite or corequisite: Phys. 2123, Math. 2308.

Fundamentals of engineering thermodynamics, thermodynamic properties of matter, the concept of conservation of energy, the second law of thermodynamics and application to engineering processes.

M.E. 3726-7. Thermodynamics
4-0-4, 3-0-3. Prerequisite or corequisite: Phys. 2123, Math. 2309.

Concepts and principles of ther-

modynamics. Applications to engineering systems and processes. Evaluation of thermodynamic properties of solids and polyatomic gases from statistical and quantum mechanics.

M.E. 3734. Environmental Technology in Architecture I

3-0-3. Prerequisite: Phys. 2113 or 2123.

Needs of modern structures. Water supply and drainage. Fire protection. Environmental comfort. Design heat load calculations. Generation, transport and distribution of heat with associated costs.

Text: at the level of McGuinness, et al., *Mechanical and Electrical Equipment for Buildings*.

M.E. 3735. Environmental Technology in Architecture II

2-3-3. Prerequisite: M.E. 3734.

Effects of solar energy. Cooling load estimates. Air conditioning systems. Delivery methods. Energy management, conservation and total energy systems. Latest topics in environmental control.

Text: at the level of McGuinness, et al., *Mechanical and Electrical Equipment for Buildings*.

M.E. 3753. Materials Laboratory

0-3-1. Prerequisite or corequisite: E.S.M. 3301.

Basic test methods of determining and evaluating phenomenological properties of engineering materials. Stress analysis instrumentation is introduced.

M.E. 4023. Engineering Acoustics and Noise Control I

3-0-3. Prerequisite: senior standing.

Study of acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, in-

strumentation, sound fields in large and small rooms, noise legislation.

M.E. 4024. Engineering Acoustics and Noise Control II

3-0-3. Prerequisite: M.E. 4023 or equivalent.

Continuation of M.E. 4023 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers enclosures, barriers, properties of materials, panel damping.

M.E. 4025. Engineering Analysis

3-0-3. Prerequisite: consent of school.

Emphasis is placed on well-ordered analytical thought processes required in the application of fundamental principles of engineering sciences to the analysis of unfamiliar engineering situations.

M.E. 4055. Experimental Engineering

1-3-2. Prerequisite: M.E. final quarter standing.

Engineering situations involving various disciplines are solved by experimental means. Students must plan experimental approach, gather data, interpret results and prepare a formal engineering report.

M.E. 4091. Seminar

1-0-1. Prerequisite: senior standing in mechanical engineering. Winter quarter only.

Civic and professional responsibilities and opportunities are brought to students by leaders in engineering, business and community affairs.

M.E. 4181. Design of Machine Elements

3-3-4. Prerequisite: E.S.M. 3301, M.E. 3212.

Methodology and practice in designing machine components by means of integrating the general principles and empiricisms of solid mechanics, materials, metal fatigue and other disciplines.

M.E. 4183. Design Theory

3-0-3. Prerequisite or corequisite: M.E. 4181.

The design process including the topics of creativity, probability, the use of statistical methods, reliability theory, decision theory, optimization and the patent system.

M.E. 4184. Design Engineering

0-6-2. Prerequisite: final quarter standing.

The design process is applied to real multidisciplinary problems by a team. Problems selected from a broad spectrum of interest areas, including biomedical, ecological, environmental.

M.E. 4185. Mechanics of Machines

3-3-4. Prerequisite: M.E. 3114, Math. 2309.

Continuation of M.E. 3114 with emphasis on the analysis of complex machines. Instrumentation and analog computer simulation of mechanisms.

M.E. 4186. Biomechanical Design

3-3-4. Prerequisite: M.E. 4445 or equivalent.

Design of systems utilizing human operator dynamics in the loop. Biological systems treated as structures, power sources and information systems, operator modeling.

M.E. 4187. Kinematic Design

2-3-3. Prerequisite: M.E. 3113 or consent of school.

The design of mechanisms to generate specified point paths or analytical functions. Graphical and analytical design methods are shown.

Text: at the level of Hartenberg and Denavit, *The Kinematic Synthesis of Mechanisms*.

M.E. 4188. Cams and Gears

3-0-3. Prerequisite: M.E. 3113 or equivalent.

Selection and design of gears. Spur, bevel, helical and worm gearings are treated. Cam design with applications including high speed systems.

M.E. 4204. Manufacturing Processing: Machining and Deformation

2-3-3. Prerequisite: M.E. 4212, E.S.M. 3301.

Theory and application of metal machining. Effects of work material, tool material and geometry, feed, speed and other variables are studied.

M.E. 4205. Manufacturing Processing: Casting and Joining

2-3-3. Prerequisite: M.E. 4212, E.S.M. 3301.

An intermediate level treatment of two important manufacturing operations, emphasis on the engineering and technological aspects of these processes, applications and design criteria.

M.E. 4212. Material Processes

3-3-4. Prerequisite: M.E. 3212.

Fundamentals of various techniques for solidification, working and shaping materials. Machining, casting, joining and metal forming are major topics. Laboratory practice supplements classroom treatment.

M.E. 4263. Mechanical Testing of Materials

3-3-4. Prerequisite: either Met. 3301, M.E. 3212 or consent of school.

Destructive and non-destructive test methods for metallic and non-metallic materials. Emphasis on the significance of results and the choice of materials based on test data.

M.E. 4265. Materials Science and Engineering

3-0-3. Prerequisite: M.E. 3212.

Advanced studies of metals, polymers, ceramics. Atomic and molecular structure, crystal binding, defects, relationship of properties to microstructures. Phase equilibria, strengthening, failure, steel constituents, hardenability.

M.E. 4316. Thermal Systems Design I

3-0-3. Prerequisite or corequisite: M.E. 3324, 4344.

Analysis, design and optimization of systems and components with examples from power generation, propulsion and refrigeration, including influence of working fluid on system and component performance.

M.E. 4317. Thermal Systems Design II

2-3-3. Prerequisite: M.E. 4316.

Energy conservation schemes, total energy systems and their characteristics. Laboratory work is related to prediction and experimental verification of system and component performance.

M.E. 4320. Internal Combustion Engines

3-3-4. Prerequisite: M.E. 3324, 3343.

Principles, practice and characteristics of internal combustion engines with experimental laboratory in engine testing and performance.

M.E. 4321. Principles of Air Conditioning

3-3-4. Prerequisite: M.E. 3324, 4344 or consent of school.

Psychrometric principles. Thermal comfort. Load estimates. Environmental control. System design using load wedge and supply area concepts. Experiments to determine components and system performance.

M.E. 4322. Power Plant Engineering

3-3-4. Prerequisite: M.E. 3324, 4344 or consent of school.

Steam and gas turbine power cycles. Modern power plants. Combined power plants. Energy and availability analysis. Economics of power generation. Design problems and field trips.

Text: at the level of Skrotzki and Vopat, *Power Station Engineering and Economics*.

M.E. 4326. Principles of Turbomachinery

3-0-3. Prerequisite: M.E. 3344 or consent of school.

Head, flow and power relationships for turbomachines and their systems. Design of impellers and casings for various types of compressors, turbines and pumps.

M.E. 4327. Combustion and Flames

3-0-3. Prerequisite: M.E. 3324, 4344 or equivalent.

Stoichiometric and thermochemical analysis of fuel-oxidant reactions. Heat and mass transfer with chemical reaction applied to combustion of gas jets, solid and liquid fuels.

M.E. 4328. Elements of Rocket Systems

3-0-3. Prerequisite or corequisite: M.E. 4344.

Basic elements, ballistics and technical problems associated with the design of propulsion systems for solid and liquid propellant rockets are studied.

M.E. 4329. One-Dimensional Compressible Flow

3-0-3. Prerequisite or corequisite: M.E. 4344.

Fundamentals of one-dimensional steady and unsteady compressible flows. Isentropic flows, flows with friction and heat transfer and with shocks are examined.

M.E. 4331. Refrigeration

3-0-3. Prerequisite: M.E. 3324.

Refrigeration cycles and systems. Balanced design concepts in selecting components. System performance at off-design conditions. Heat pumps.

Text: at the level of Stoecker, *Refrigeration and Air Conditioning*.

M.E. 4339. Gas Turbines

3-0-3. Prerequisite: M.E. 3324, 3344.

Applications of gas turbines including limitations and advantages as compared with other prime movers. Design of compressor, combustor and turbine components.

M.E. 4343. Heating, Ventilating and Air Conditioning Design

3-0-3. Prerequisite: M.E. 4321.

Sizing of equipment for environmental control. Design of transportation and delivery systems. Energy recovery schemes. Total energy concepts and design features.

M.E. 4344. Transport Phenomena IV

3-0-3. Prerequisite: M.E. 3344.

Fundamentals of transport process applied to free and forced

convection, boundary layer applications, similarity and modeling, external and internal flows, change of phase, heat exchangers. Applications.

M.E. 4347. Elements of Nuclear Power

3-0-3. Prerequisite: M.E. 4344 or equivalent.

Nuclear energy generation, fuels, materials, radiation damage, shielding and safety. Nuclear reactors: boiling water, pressurized water, gas cooled and fast breeder reactors.

M.E. 4357. Plasmas and Engineering Applications

3-0-3. Prerequisite: undergraduate thermodynamics, senior standing.

Occurrence of plasmas, review of electromagnetic theory, thermodynamics of ionized gases, equations of magnetohydrodynamics, MHD waves, channel flow, application to electric arcs, MHD energy conversion and fusion.

M.E. 4445. Automatic Control

3-0-3. Prerequisite: Math. 2309.

Analysis and modeling of linear systems and compensation of feedback controlled systems using classical methods. Hydraulic, pneumatic, thermal, electrical, nuclear, chemical and biomechanical examples.

Text: at the level of Dorf, *Modern Control Systems*.

M.E. 4448. Fluidics

3-3-4. Prerequisite: M.E. 3344, 4445 or equivalent.

Analysis and design of analog and digital fluidic devices and systems. Line dynamics, power economy, reliability, staging and interconnection characteristics are considered.

M.E. 4449. Numerical Control of Machine Tools

3-0-3. Prerequisite or corequisite: M.E. 4445.

Study of design and operation of typical digital control systems for machine tools, including the flow of signals through the system.

M.E. 4714. Heat Transfer

3-0-3. Prerequisite: M.E. 3720, 3016 or equivalent. Not for M.E. students.

Transport processes, concepts of conduction, convection and radiation. Boundary layer analysis in convective laminar and turbulent flows. Stationary systems, including external/internal resistance criteria.

M.E. 4780. Energy Conversion Engineering

3-0-3. Prerequisite: M.E. 3720 or equivalent.

Energy sources, basic principles of semiconductors, thermoelectric converters, solar power, thermionic systems, MHD, applications of these devices for power generation, environmental effects, cost factors.

Text: at the level of Angrist, *Direct Energy Conversion*.

M.E. 4801-2-3-4-5. Special Topics, Mechanical Engineering

1-0-1 to 5-0-5 respectively.

Special topic offerings of current interest and not included in regular courses.

M.E. 4901 through 4912. Special Problems, Mechanical Engineering

Credit to be arranged.

Individual studies in certain specialized areas, and mathematical analyses and/or experimental investigations of problems of current interest in mechanical engineering.

M.E. 6014. Engineering Instrumentation

3-3-4. Prerequisite: M.E. 3055 or equivalent or graduate standing.

Methods and techniques of modern instrumentation in engineering research. Emphasis on analytical methods in planning and evaluation of experiments, integration of experimentation theory with practical aspects of instrumentation problems.

M.E. 6024-5. Variational Methods in Engineering

3-0-3 each. Prerequisite: M.E. 4344, E.S.M. 3302 or equivalent.

Variational methods applied to the optimization of engineering systems, the formulation and approximate solution of differential equations with application to non-linear vibration, fluid mechanics, heat transfer, hydrodynamic stability and automatic control.

M.E. 6121. Advanced Dynamics of Machinery

3-0-3. Prerequisite: consent of school.

Design-oriented dynamics. Dynamics of systems with constraints, application of virtual work-minimum potential to systems, dynamical equations of Lagrange, Hamilton.

M.E. 6122. Machine Vibration

3-0-3. Prerequisite: consent of school.

Application of dynamic theory to practical situations, natural frequencies of systems, impact, impulse and momentum, discrete and continuous system techniques, periodic and random sources.

M.E. 6125. Mechanism Synthesis I

3-0-3. Prerequisite: M.E. 4187 or equivalent.

A continuation of M.E. 4187. Advanced topics in curvature theory. Finite displacement of a plane, Burmester theory. Current developments in kinematics. Graphical and analytical design methods.

Text: at the level of Hartenberg and Denavit, *The Kinematic Synthesis of Mechanisms*.

M.E. 6126. Mechanism Synthesis II: Computer Methods

2-3-3. Prerequisite: M.E. 6125.

Analog-computer simulation of linkages. Complex-number approach to linkage synthesis. Digital computation of Sandor-Freudenstein and Bloch. "Best fit" by Chebyshev polynomial approximations.

M.E. 6127. Spatial Mechanisms

3-0-3. Prerequisite: M.E. 6125.

The analysis and synthesis of three-dimensional linkages in general. Extension of the Grubler theory, number theory, special mechanisms.

M.E. 6133. Elastic Yield Designs of Machine Members

3-0-3. Prerequisite: consent of school.

The methods of strain-energy, virtual work, area-moment and Castigliano's theorem are applied to the design of machine members against excessive deformation.

M.E. 6170. Engineering Design

3-6-5. Prerequisite: consent of school.

Design concepts, life design, fatigue and failure, thermal stress, and the elements of optimum design are studied.

M.E. 6239. Materials for Design

3-0-3. Prerequisite: M.E. 4212.

Properties, behavior and selection of materials for practical

design applications. Topics include effects of elastic and plastic deformation, brittle fracture, fatigue, creep and corrosion.

M.E. 6240. Advanced Materials for Design

3-0-3. Prerequisite: M.E. 6239.

Advanced studies of materials, their properties, selection and applications to high and low temperature environments. Economic, engineering and design considerations are emphasized.

M.E. 6271. Deformation of Metals

3-0-3. Prerequisite: M.E. 4212.

Advanced study of atomic structure and imperfections in crystalline solids. Topics include plastic deformation, strain hardening, annealing processes, creep, fatigue, ductile and brittle fracture.

M.E. 6272-3. Fabrication of Metals

3-0-3. Prerequisite: M.E. 6271.

Fabrication processes of metals including forging, rolling, extrusion, drawing, deep drawing and pressing. Frictional phenomena, slip line fields, upper bound forces, material properties and characteristics.

Text: at the level of Backofen, *Deformation Processing*.

M.E. 6322. Thermodynamics I

3-0-3. Prerequisite: undergraduate thermodynamics.

Thorough study of the principles and macroscopic formalism of thermodynamics. Thermodynamic systems, pure substance, multi-phase mixtures, reactive systems.

M.E. 6323. Thermodynamics II

3-0-3. Prerequisite: undergraduate thermodynamics.

Microscopic thermodynamics based on classical mechanics,

quantum mechanics and information theory. Prediction of macroscopic properties and system behavior from statistical considerations.

M.E. 6324. Thermodynamics III

3-0-3. Prerequisite: M.E. 6323 or equivalent.

Statistical thermodynamic calculation of properties of ideal gases, real gases, solids and gas mixtures. Kinetic theory and transport properties. Thermodynamics of special systems.

M.E. 6325. Information Theory Thermodynamics

3-0-3. Prerequisite: M.E. 6323 or consent of school.

A derivation from information theory of the fundamentals of thermodynamics and statistical mechanics. Applications to irreversible thermodynamics and the design of thermo-systems.

M.E. 6332. Heat Transfer I

3-0-3. Prerequisite: M.E. 4344 or consent of school.

Conduction – steady state and transient, one and multi-dimensional geometries. Emphasis on analytical methods – exact and approximate, on numerical and graphical techniques.

M.E. 6333. Heat Transfer II

3-0-3. Prerequisite: M.E. 6332 or consent of school.

Convection – forced and free, in laminar and turbulent, internal and external flows. Analogy between momentum and heat transfer. Scaling laws and partial modeling.

M.E. 6334. Heat Transfer III

3-0-3. Prerequisite: graduate standing.

Radiation – electrodynamics,

radiation optics, photon gas concept, black body radiation, surface characteristic, exchange in enclosures, radiation through continua, experimental methods.

M.E. 6338. Advanced Theory of Heat Transfer

3-0-3. Prerequisite: M.E. 6332, 6333.

Advanced mathematical methods in conduction and convection, ablation, solidification, packed and fluidized beds, condensation, boiling heat transfer, heat transfer in porous media, transient boundary layers.

M.E. 6342. Fluid Flow I

3-0-3. Prerequisite: M.E. 3343 or consent of school.

A general development of the continuity, linear and angular momentum and energy equations followed by the fundamentals of perfect fluid theory.

M.E. 6343. Fluid Flow II

3-0-3. Prerequisite: M.E. 6342 or equivalent.

Viscous flow theory including derivation of Navier-Stokes equations, a study of their general properties and their applications to creeping flow and to laminar and turbulent boundary layers.

M.E. 6344. Fluid Flow III

3-0-3. Prerequisite: M.E. 6343 or equivalent.

Turbulent flow theory, origins of turbulence, turbulent stress, mixing-length models, free turbulent flow, flow in pipes and boundary layers, statistical description of turbulence.

M.E. 6349. Theory of Jets

3-0-3. Prerequisite: M.E. 6343, 6344 or equivalent.

Laminar and turbulent jet flows in free and confined spaces.

M.E. 6351. Direct Energy Conversion

3-0-3. Prerequisite: M.E. 3720 or equivalent.

Analysis of performance characteristics, based on thermodynamic and fluid flow principles of direct energy conversion devices such as thermionic, thermoelectrics, photovoltaic, magnetohydrodynamic, electrohydrodynamic generators and fuel cells.

Text: at the level of Kettani, *Direct Energy Conversion*.

M.E. 6352. Energy Conversion Systems

3-0-3. Prerequisite: M.E. 3324 or equivalent.

A study of alternative energy conversion systems and analysis of their economic and commercial performance characteristics. Comparative analysis of Otto, Diesel, Brayton, Rankine, solar and direct energy conversion systems.

M.E. 6353. Diagnostics of Combustion Gases and Plasmas

3-0-3. Prerequisite: statistical thermodynamics.

Study of diagnostic techniques for combustion gases and plasmas. Review of relevant physical phenomena. Spectroscopic, interferometric, laser and probe techniques. Treatment includes latest techniques and procedures.

M.E. 6355. Combustion I

3-0-3. Prerequisite: graduate standing.

Conservation laws and constitutive equations in reactive media. Reactions kinetics, laminar and turbulent diffusion flames.

M.E. 6356. Combustion II

3-0-3. Prerequisite: M.E. 6355 or equivalent.

Combustion of liquid and solid fuels. Combustion in laminar boundary layers.

M.E. 6357. Combustion III

3-0-3. Prerequisite: M.E. 6356 or equivalent.

Combustion in turbulent boundary layers. Spontaneous ignition and explosions. Flame propagation and flammability limits.

M.E. 6370. Thermal Environmental Control

3-0-3. Prerequisite: consent of school.

Thermodynamic relations of moist air. Air conditioning processes. Environmental systems for thermal comfort. Direct and indirect contact transport processes.

Text: at the level of Threlkeld, *Thermal Environmental Engineering*.

M.E. 6371. Advanced Refrigeration

3-0-3. Prerequisite: consent of school.

Development of design and performance characteristics of vapor compression, absorption and several other work and heat input refrigeration cycles. Specification of desirable refrigerant properties.

M.E. 6376. Internal Combustion Engine Design

3-0-3. Prerequisite: undergraduate design, M.E. 4320 or equivalent.

Internal combustion engine design practice to accommodate challenges of application, efficiency, emissions and balance.

M.E. 6377. Internal Combustion Engines

3-0-3. Prerequisite: M.E. 6355 or equivalent.

Principles of operation of reciprocating and rotating engines

including analysis of pollutant formation and methods of its control.

M.E. 6379. Turbines

3-0-3. Prerequisite: either M.E. 4339, 4326 or consent of school.

Basic fluid mechanics and thermodynamics of the expansion processes in various types of radial and axial flow turbines. Current literature is discussed.

M.E. 6383. Lubrication

3-0-3. Prerequisite: consent of school.

Hydrodynamic, hydrostatic, liquid and gas lubrication, elastohydrodynamic lubrication, lubricant properties, boundary lubrication, friction and solid lubricants are covered from fundamental development through design considerations.

M.E. 6424. Feedback Control Systems I

3-0-3. Prerequisite: graduate standing.

Linear systems. Integration of classical (root locus, frequency response) and modern (state feedback, observers) techniques. Mechanical, thermal, fluid, chemical and nuclear examples.

M.E. 6425. Feedback Control Systems II

3-0-3. Prerequisite: either M.E. 4445, 6424 or equivalent.

Discrete time and nonlinear systems. Sampled data and digital control. Phase plane, describing functions and Lyapunov methods.

M.E. 6426. Feedback Control Systems III

3-0-3. Prerequisite: M.E. 6424 or equivalent.

Optimal systems. Maximum principle and dynamic programming. Quadratic linear optimization.

tion. Kalman filtering. Computational methods.

M.E. 6437-8. Digital Control Systems I and II

3-0-3,3-3-4. Prerequisite: graduate standing or consent of school. M.E. 6437 is prerequisite for 6438.

A study of the basic theory and techniques employed in the design of control systems for numerically controlled machine tools and digital computers is conducted.

M.E. 6439. Control System Components

2-1-3. Prerequisite: M.E. 4445 or equivalent.

A study of the performance characteristics and the mathematical modeling of control system components, including transient and frequency response tests, is conducted.

M.E. 6440. Fluid-Power Control Systems

3-0-3. Prerequisite: M.E. 4445 or equivalent.

Analysis and synthesis of control systems using liquids and gases. Dynamic characteristics and specifications of control system components, closed-loop fluid-power control systems.

M.E. 6471. Control of Engineering Processes

3-0-3. Prerequisite: M.E. 6424 or equivalent.

Large-scale computer solutions and simulation. Distributed parameter system modeling and analysis. Current interest topics of practical significance not in M.E. 6424-5-6.

M.E. 6750. Systems Design Methodology

2-3-3. Prerequisite: graduate standing or consent on school.

Relationship of technological systems to society is studied using economic concepts. Emphasis on the use of engineering type analysis in resolving value laden problems. Examples. Cross-listed with A.E., E.E., C.E., C.P., I.Sy.E.

M.E. 6751-2. Complex Systems Design

2-4-3 each. Prerequisite: graduate standing in any school or senior with consent of school.

Interdisciplinary team design of systems of current interest to society which have large technological factors. Individual research and interaction with non-institute resource persons and faculty. Grades based on oral and written reports. Cross-listed with A.E., E.E., C.E., C.P., I.Sy.E.

M.E. 6760-1. Acoustics I and II

3-0-3 each. Prerequisite: Math. 4349 or consent of school.

Governing equations of sound waves from the conservation laws. Acoustic momentum, energy and intensity. Propagation, reflection, absorption and scattering. Effects of the physical properties. Application of the theory of sound to real systems. Transmission of sound in real media.

M.E. 6762. Acoustics III

3-0-3. Prerequisite: M.E. 6761.

Advanced duct acoustics, wave dispersion and attenuation, acoustics in moving media, geometrical acoustics, nonlinear acoustics.

M.E. 6763. Noise Reduction and Control (Industrial Applications)

3-0-3. Prerequisite: M.E./A.E./E.S.M. 6760, M.E. 4023 or equivalent.

Methods of noise reduction and control applied to systems in industry. Measurement of sound

power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction and damping methods.

M.E. 6999. Master's Thesis Topic Selection

Non-credit. Prerequisite: consent of school.

M.E. 7000. Master's Thesis

M.E. 7035. Numerical Methods in Mechanical Engineering

3-0-3. Prerequisite: graduate standing.

Numerical analysis of deterministic engineering systems. Numerical approximations to mathematical operations. Initial and boundary value problems. Computational stability for ordinary and linear partial differential equations.

M.E. 7122. Advanced Machine Vibrations

3-0-3. Prerequisite: M.E. 6122 or consent of school.

Applications of vibration theory. Machinery response on resilient mounting. Kinematic and dynamic stability. Nonlinear systems in electromechanical and mechanical design.

M.E. 7136. Design of Resilient Machine Members

3-0-3. Prerequisite: M.E. 6122 or equivalent.

Analysis and design for transient external and internal stress for machine members. Effects of impact loading. Criteria for yielding and failure. Numerical techniques and applications.

M.E. 7140. Decision Theory for Engineering Design

3-0-3. Prerequisite: Math. 4215 or consent of school.

Use of information-theory deci-

sion analysis in solving practice problems in engineering design and reliability which cannot be effectively treated by any other methods.

M.E. 7220. High Temperature Deformation Processes

3-0-3. Prerequisite: M.E. 4265.

Mechanical properties of materials at elevated temperatures, creep behavior, deformation mechanisms, stress analysis. Design for temperature effects, thermal stress, notches, fracture, fatigue, corrosion and oxidation.

M.E. 7222-3. Fracture and Fatigue of Material I, II

3-0-3 each. Prerequisite: M.E. 6221.

Advanced study of failure of structural materials under load. Mechanics of fracture, microscopic and macroscopic aspects, fracture of specific materials: steels, nonferrous alloys, nonmetallic materials.

Text: at the level of Tetelman and McEvily, *Fracture of Structural Materials*.

M.E. 7322. Thermodynamics of Irreversible Processes I

3-0-3. Prerequisite: graduate standing.

Principles and formalism of thermodynamics of near-equilibrium states. Phenomenological equations and the Onsager-Casimir reciprocal relations. Coupled linear processes and cross-effects.

M.E. 7323. Thermodynamics of Irreversible Processes II

3-0-3. Prerequisite: M.E. 7322 or equivalent.

Further study of the application of irreversible thermodynamics in linear processes. Variational formulation for nonequilibrium thermodynamics, current contributions

towards the solution of nonlinear problems.

M.E. 7336. Forced Convection Heat Transfer

3-0-3. Prerequisite: M.E. 6333.

Theory of forced convection heat exchange in recuperators, regenerators and devices with simultaneous heat and mass transfer, with emphasis on performance and thermal design.

Text: at the level of Jakob, *Heat Transfer*, volume two.

M.E. 7338. Advanced Topics in Heat Transfer

3-0-3. Prerequisite: M.E. 6332, 6333, 6334.

Latest advances in heat transfer, boiling and two-phase flows, liquid metal heat transfer, influence of main stream turbulence, separated flows, porous media, radiation and conduction.

M.E. 7341. Transport Phenomena in Two-Phase Flow I

3-0-3. Prerequisite: consent of school.

Dispersed and separated flows – field and constitutive equations, jump conditions. Interfacial phenomena, nucleation. Two-fluid and drift models, similarity, criteria. Dynamics, propagation phenomena, kinematic waves.

M.E. 7342. Transport Phenomena in Two-Phase Flow II

3-0-3. Prerequisite: consent of school.

Flow regimes, pressure drop, void fraction. Boiling forced convection vaporization. Atomization. Burn out and critical heat flux. Spray cooling. Condensation phase separation.

M.E. 7760. Magnetogasdynamics I

3-0-3. Prerequisite: graduate standing.

Thermodynamic, transport and electrical properties of plasmas. Magnetic effects. Microscopic and macroscopic description. Derivation of continuity, momentum and energy equations for hydro-magnetic flow. Electrodes. Cross-listed with A.E.

M.E. 7761. Magnetogasdynamics II

3-0-3. Prerequisite: M.E. 7760 or equivalent.

Study of magnetogasdynamics flow phenomena. Instabilities of plasmas. Turbulence. Electromagnetic wave propagation in plasmas. Optical radiation from plasmas. Production of plasmas: electrical discharges, laser, shock wave and flame plasmas. Cross-listed with A.E.

M.E. 7762. Magnetogasdynamics III

3-0-3. Prerequisite: M.E. 7760 or equivalent.

Engineering applications of magnetogasdynamics. Power generation with MHD systems. MHD channel materials. Magnetic field coils. Economics of MHD systems. Propulsion systems. Plasma chemistry. Arc applications.

M.E. 7763. Methods of Experimental Magnetogasdynamics

2-3-3. Prerequisite: M.E. 7761 or equivalent.

Laboratory plasma sources and flow facilities. Discussion of various arc configurations. Topics in plasma diagnostics. Field trip to representative facilities.

M.E. 7999. Preparation for Doctoral Qualifying Exam

Non-credit. Prerequisite: consent of school.

M.E. 8039. Heat Transfer Seminar

1-0-1.

Two presentations by each stu-

dent of current research activities: thesis work and special problems, presentation of thesis proposals. Attendance in curriculum-related seminars.

M.E. 8041-2-3-4-5. Fluid Mechanics Seminar

1, 2, 3, 4, 5 credit hours respectively. Prerequisite: consent of school.

Advanced current topics in fluid mechanics and fluid engineering including applications of interest to mechanical engineering.

M.E. 8101-2-3-4-5. Special Topics in Design

1, 2, 3, 4, 5 credit hours respectively. Prerequisite: consent of school.

Special topic offerings of current interest and not included in regular courses.

M.E. 8201-2-3-4-5. Special Topics in Materials

1, 2, 3, 4, 5 credit hours respectively. Prerequisite: consent of school.

Special topic offerings of current interest and not included in regular courses.

M.E. 8301-2-3-4-5. Special Topics in Energetics

1, 2, 3, 4, 5 credit hours respectively. Prerequisite: consent of school.

Special topic offerings of current interest and not included in regular courses.

M.E. 8401-2-3-4-5. Special Topics in Systems and Controls

1, 2, 3, 4, 5 credit hours respectively. Prerequisite: consent of school.

Special topic offerings of current interest and not included in regular courses.

M.E. 8501 through 8517. Special Problems in Mechanical Engineering

Credit to be arranged. Prerequisite: consent of school.

Individual studies in certain specialized areas and mathematical analyses and/or experimental investigations of problems of current interest in mechanical engineering.

M.E. 8999. Preparation for Doctoral Dissertation

Non-credit. Prerequisite: consent of school.

M.E. 9000. Doctoral Thesis

Military Science

Basic Courses

M.S. 1040. Leadership Development

0-1-0.

A weekly period devoted to furtherance of basic military skills, leadership, drill and command. Command voice and individual execution are stressed.

M.S. 1100. Orientation: The Military Role in Perspective

1-1-1.

Detailed orientation to the Georgia Tech ROTC program, the role of the military officer, the national security organization and Department of the Army mission and organization.

M.S. 1200. Terrain Analysis and Land Navigation

1-1-1.

A study of military maps and general photographs for terrain analysis and land navigation. A study of military symbology in operational planning.

M.S. 2100. Analysis of Command and Leadership

2-1-2.

A study of group dynamics, individual motivation and the func-

tion of leadership at the small unit level. An examination of peer group relations.

M.S. 2200. Seminar on Communications and Instructional Methods
2-1-2.

Studies in fundamental techniques and methods of instruction with emphasis on individual presentation, group conferences and critiques.

M.S. 2300. Military History
3-1-3.

A study of U.S. military history, emphasizing the principles of war and the effects of underlying political, economic, social and technological factors.

Required Advanced Courses

M.S. 3040. Leadership Development

0-1-0. Prerequisite: advanced ROTC standing.

A weekly period devoted to furtherance of intermediate leadership and management skills, stressing effective oral communications and instructions.

M.S. 3100. Tactical Decision-making

3-1-3. Prerequisite: advanced ROTC standing.

Application of tactical decision-making at the small unit level. Practical experience in planning tactical operations.

M.S. 4040. Leadership Development

0-1-0. Prerequisite: advanced ROTC standing.

A weekly period devoted to furtherance of advanced leadership and management skills. Cadets plan, organize and execute

the entire leadership development program.

M.S. 4100. Military Administrative Operations

2-1-1. Prerequisite: advanced ROTC standing.

A study of the basic concepts and fundamentals of military administration and military justice.

Branch Material Courses

Air Defense Artillery

M.S. 3130. Forward Area Air Defense

3-1-3. Prerequisite: advanced ROTC standing.

An introduction to the Army Air Defense forces with emphasis on the forward area air defense weapons employed with the Army in the field.

M.S. 4130. Air Defense Missile Systems

3-1-3. Prerequisite: advanced ROTC standing.

A study of the Army Air Defense missile systems utilized to protect military and civilian assets both in the United States and overseas.

Corps of Engineers

M.S. 3330. Combat Engineering

3-1-3. Prerequisite: advanced ROTC standing.

A study of military engineering in a combat environment. Emphasis is placed on combat engineer units, equipment and methods of employment in a combat situation.

M.S. 4330. Military Construction Management

3-1-3. Prerequisite: advanced ROTC standing.

A study of construction manage-

ment as applied to military construction to support combat operations. Emphasis is placed on construction project planning and control techniques.

Infantry

M.S. 3430. Tactics and Techniques of Small Unit Operations

3-1-3. Prerequisite: advanced ROTC standing.

A study of the fundamentals and principles of Infantry tactics at the small unit level, including the organization of Infantry, Armored, Airmobile and Airborne Divisions.

M.S. 4430. Advanced Infantry Tactics and Techniques

3-1-3. Prerequisite: advanced ROTC standing.

A study of staff and command actions, estimates and orders in the employment of Infantry units and supporting elements from other branches and services.

Ordnance Corps

M.S. 3530. Ordnance Tactics and Techniques

3-1-3. Prerequisite: advanced ROTC standing.

An analysis of the characteristics, capabilities and trends in Army materiel and their impact on logistics management. Unique Ordnance tactics and techniques are discussed.

M.S. 4530. Ordnance Management.

3-1-3. Prerequisite: advanced ROTC standing.

An analysis of management theories, concepts and practices. Emphasis is on management functions, human relations and interpersonal communications as they relate to the Ordnance officer.

Signal Corps

M.S. 3630. Tactical Communications – Electronic Systems

3-1-3. Prerequisite: advanced ROTC standing.

A study of signal field communications system engineering and communications control in units below division level, including wire, radio and multichannel communications systems.

M.S. 4360. Strategic Communications – Electronic Systems

3-1-3. Prerequisite: advanced ROTC standing.

An analysis of division, corps and field army communications. A study of U.S. Army Strategic Communications Command communications requirements and facilities, to include satellite communications.

Modern Languages

Chinese

Chin. 1001. Introduction to Mandarin Chinese

3-2-4. Prerequisite: one year college-level foreign-language study or equivalent and consent of department.

Intensive study of patterns of expression in spoken Chinese.

Chin. 1002. Introduction to Mandarin Chinese

3-2-4. Prerequisite: Chin. 1001 or equivalent.

Continuation of Chin. 1001, introduction to Chinese writing system.

Chin. 1003. Introduction to Mandarin Chinese

3-2-4. Prerequisite: Chin. 1002 or equivalent.

Continuation of Chin. 1002,

proportionately more emphasis on written Chinese.

Chin. 4901-2-3-4. Special Problems in Chinese

Credit to be arranged.

Provides the special instruction required under special programs.

French

Fren. 1001. Elementary French

3-0-3.

Essential principles of French phonetics, acquisition of vocabulary through simple conversational exercises and the reading of simple selections.

Fren. 1002. Elementary French

3-0-3. Prerequisite: Fren. 1001 or equivalent.

Continuation of Fren. 1001, extension of the survey of French grammar, acquisition of a general vocabulary through conversation and reading.

Fren. 1003. Elementary French

3-0-3. Prerequisite: Fren. 1002 or equivalent.

Reading of selected texts, composition, completion of the survey of French grammar.

Fren. 2001. Period: The Beginning to 1700

3-0-3. Prerequisite: Fren. 1003 or equivalent.

History of France. Social evolution and the psychology which engendered France's artistic contributions to civilization in numerous areas.

Fren. 2002. Period: 1700 to 1800

3-0-3. Prerequisite: Fren. 2001 or equivalent.

History of France. France's contribution to the democratic ideal

and the fine arts. Readings from Montesquieu, Voltaire, Rousseau and others.

Fren. 2003. Period: 1800 to the Present

3-0-3. Prerequisite: Fren. 2002 or equivalent.

History of France. Readings from authors identified with the progress of democratic ideals and the scientific awakening.

Fren. 3001. Period: 1800-1850

3-0-3. Prerequisite: Fren. 2003 or equivalent.

Literature of France. Romanticism, the reappearance of lyric poetry, the importance of the individual as opposed to classical anonymity. Conducted in French.

Fren. 3002. Period: 1850-1900

3-0-3. Prerequisite: Fren. 2003 or equivalent.

Literature of France. Parnassianism and symbolism, developments in poetry, realism and naturalism, trends in prose, with emphasis on the development of the novel. Conducted in French.

Fren. 3003. Period: 1900 to the Present

3-0-3. Prerequisite: Fren. 2003 or equivalent.

Literature of France. Exploration of currents in modern prose, poetry and drama. Conducted in French.

Fren. 3011. France Today I

3-0-3. Prerequisite: Fren. 2003 or consent of department.

Culture, history and geography of modern France in lectures and class discussions, short papers on assigned topics, series conducted in French.

Fren. 3012. France Today II

3-0-3. Prerequisite: Fren. 3011 or consent of department.

Continuation of Fren. 3011.

Fren. 3013. France Today III

3-0-3. Prerequisite: Fren. 3011-2 or consent of department.

Continuation of Fren. 3012.

Fren. 4001. Introduction to French Stylistics

3-0-3. Prerequisite: Fren. 3003 or equivalent.

Advanced study of grammar and usage, aimed at development of stylistic sensitivity. Compositions in French.

Fren. 4002. Classic French Literature

3-0-3. Prerequisite: Fren. 3003 or equivalent.

Survey of French classic literature, readings in Malherbe, Descartes, Pascal, La Rochefoucauld, La Fontaine, La Bruyere, in Corneille, Moliere and Racine. Lectures on the Classic Age; term report.

Fren. 4003. The French Novel

3-0-3. Prerequisite: Fren. 3003 or equivalent.

Survey of the development of the French novel from the late seventeenth century through the twentieth century, term report.

Fren. 4075. Intensive Readings in French I

3-0-3. Prerequisite: junior standing or consent of department.

Acquisition in one quarter of as much French as is normally acquired in two. Aim: development of linguistic competence for reading and comprehension.

Fren. 4076. Intensive Readings in French II

3-0-3. Prerequisite: Fren. 4075.

Continuation of Fren. 4075, with comparable achievement as objective.

Fren. 4077. Intensive Readings in French III

3-0-3. Prerequisite: Fren. 4076.

Continuation of Fren. 4076, with comparable achievement as objective.

Fren. 4091-2-3. French Study Abroad

5-0-5 each.

The Study Abroad Program of the University System of Georgia. Fifteen quarter hours credit for summer study abroad.

Fren. 4901-2-3-4. Special Problems in French

Credit to be arranged.

Provides the special instruction required under special programs.

German

Ger. 1001. Elementary German

3-0-3.

Pronunciation, essential principles of German grammar, rapid acquisition of vocabulary by the reading of simple selections, elementary composition.

Ger. 1002. Elementary German

3-0-3. Prerequisite: Ger. 1001 or equivalent.

Continuation of Ger. 1001.

Ger. 1003. Elementary German

3-0-3. Prerequisite: Ger. 1002 or equivalent.

Reading of general German material and the acquisition of a large vocabulary, continued study of German grammar, composition.

***Ger. 2001. Introduction to Modern German Culture I**

3-0-3. Prerequisite: Ger. 1003 or equivalent.

Selected readings in German on the cultural, historical and intellectual development of Germany. Class discussion of reading material.

***Ger. 2002. Introduction to Modern German Culture II**

3-0-3. Prerequisite: Ger. 2001 or equivalent.

Continuation of Ger. 2001.

***Ger. 2003. Introduction to Modern German Culture III**

3-0-3. Prerequisite: Ger. 2002 or equivalent.

Continuation of Ger. 2002.

***Ger. 2011 Intermediate German (Scientific)**

3-0-3. Prerequisite: Ger. 1003 or equivalent.

Reading of German scientific and technical material, individual problems to conform, whenever possible, with the student's special field of study.

***Ger. 2012. Intermediate German (Scientific)**

3-0-3. Prerequisite: Ger. 2011 or equivalent.

Continuation of training given in Ger. 2011.

***Ger. 2013. Intermediate German (Scientific)**

3-0-3. Prerequisite: Ger. 2012 or equivalent.

Reading of German prose in support of the development achieved in Ger. 2011 and 2012.

Ger. 3001. Introduction to German Literature I

3-0-3. Prerequisite: Ger. 2003, 2013 or equivalent.

Literary masterpieces in German. Period: medieval times – 1750.

Ger. 3002. Introduction to German Literature II

3-0-3. Prerequisite: Ger. 2003, 2013 or equivalent.

Literary masterpieces in German. Period: 1750-1840.

Ger. 3003. Introduction to German Literature III

3-0-3. Prerequisite: Ger. 2003, 2013 or equivalent.

Literary masterpieces in German. Period: 1840 to the present.

Ger. 3011. Germany Today I

3-0-3. Prerequisite: Ger. 2003 or consent of department.

German lectures, papers and class discussions of German history, urban and rural morphology, post-war social and economic development in East and West Germany.

Ger. 3012. Germany Today II

3-0-3. Prerequisite: Ger. 3011 or consent of department.

Continuation of Ger. 3011 in treatment of additional topics—German family life, educational system, church and religion, development of the arts, the Hitler era.

*Ger. 2001-2-3 is recommended for those interested in German not only as a tool of research but also as a medium of cultural development. Ger. 2011-2-3 is recommended for those interested in German as a tool of research only. Each series may be taken for full credit toward graduation, and either series may be taken first. Both series offer excellent preparation for graduate reading-knowledge examinations. But, of these two series, only Ger. 2001-2-3 satisfies the core curriculum.

Ger. 3013. Germany Today III

3-0-3. Prerequisite: Ger. 3011, 3012 or consent of department.

Continuation of Ger. 3011 and 3012, in-depth treatment of contemporary issues. Supplementary instructional media: slides, recordings, journals and panel discussions.

German 3031. The German Novelle I

3-0-3. Prerequisite: German 2003 or consent of department.

Period: 1795-1840, Goethe, Kleist, Tieck, Arnim, E.T.A. Hoffmann, Eichendorff. Conducted in German.

Ger. 3032. The German Novelle II

3-0-3. Prerequisite: German 2003 or consent of department.

Period: 1840-1885, Stifter, Keller, Storm, Ebner-Eschenbach, Meyer. Conducted in German.

Ger. 3033. The German Novelle III

3-0-3. Prerequisite: German 2003 or consent of department.

Period: 1885 to the present, Hofmannsthal, Mann, Kafka, Musil, Wiechert, Borchert, Gaiser, Piontek. Conducted in German.

Ger. 3051. The German Folksong.

3-0-3. Prerequisite: Ger. 2003, 2013 or equivalent.

Introduction to the wide range of human experience reflected in the German folksong. Emphasis on the appreciation of musical forms and literary aspects.

Ger. 4001. German Writers of the 20th Century I

3-0-3. Prerequisite: Ger. 2003, 2013 or equivalent.

Period: Naturalism—1920. Conducted in German.

Ger. 4002. German Writers of the 20th Century II

3-0-3. Prerequisite: Ger. 2003, 2013 or equivalent.

Period: 1920 to the present. Conducted in German.

Ger. 4003. Modern German Drama

3-0-3. Prerequisite: Ger. 2003, 2013 or equivalent.

A study of the leading German dramatists from the period of Naturalism to the present time. Lectures, parallel readings, discussions. Course conducted in German.

Ger. 4021. The Age of Goethe I

3-0-3. Prerequisite: Ger. 2003, 2013 or equivalent.

Period: eighteenth century to the time of Goethe and Schiller. Conducted in German.

Ger. 4022. The Age of Goethe II

3-0-3. Prerequisite: Ger. 2003, 2013 or equivalent.

The mature works of Goethe and Schiller. Conducted in German.

Ger. 4023. Selected Readings in German Literature

3-0-3. Prerequisite: Ger. 2003, 2013 or equivalent.

Study of selected authors, movements, genres and forms in German literature. Selections vary from year to year. Parallel readings, reports and papers.

Ger. 4051. Seminar in the Modern German Novel I

3-0-3. Prerequisite: Ger. 4001-2-3 or consent of department.

The novels of Franz Kafka. Conducted in German.

Ger. 4052. Seminar in the Modern German Novel II

3-0-3. Prerequisite: Ger. 4051 or consent of department.

The major novels of Hermann

Hesse. (*Demian, Narziss und Goldmund, Steppenwolf, Glasperlenspiel*). Conducted in German.

Ger. 4053. Seminar in the Modern German Novel III

3-0-3. Prerequisite: Ger. 4052 or consent of department.

Selected novels of Guenter Grass, Max Frisch and Christa Wolf. Conducted in German.

Ger. 4075. Intensive Readings in German I

3-0-3. Prerequisite: junior standing or consent of department.

Acquisition in one quarter of as much German as is normally acquired in two. Aim: development of linguistic competence for reading and comprehension.

Ger. 4076. Intensive Readings in German II

3-0-3. Prerequisite: Ger. 4075.

Continuation of Ger. 4075 with comparable achievement as objective.

Ger. 4077. Intensive Readings in German III

3-0-3. Prerequisite: Ger. 4076.

Continuation of Ger. 4076 with comparable achievement as objective.

Ger. 4091-2-3. German Study Abroad

5-0-5 each.

The Study Abroad Program of the University System of Georgia. Fifteen quarter hours credit for summer study abroad.

Ger. 4901-2-3-4. Special Problems in German

Credit to be arranged.

Provides the special instruction required under special programs.

Linguistics

Ling. 2001. Introduction to Language I

3-0-3.

Survey of major language families of the world and relationships within language families, comparison of dialects and standard languages.

Ling. 2002. Introduction to Language II

3-0-3. Prerequisite: Ling. 2001 or consent of department.

Survey of the types of linguistic change and development, comparison of generic and genetic linguistic relationships, linguistic borrowing.

Ling. 2003. Introduction to Language III

3-0-3. Prerequisite: Ling. 2002 or consent of department.

Survey of universal structural units of language, major writing systems and principles of graphological representation of languages. Methodology of descriptive linguistics.

Ling. 3001. Introduction to Articulatory Phonetics

3-0-3.

Introduction to articulatory and acoustic phonetics, methodology for analyzing sounds in various languages, with emphasis on recording sounds in phonetic script and reproduction of sounds.

Ling. 3002. Introduction to Structural Linguistics I

3-0-3. Prerequisite: Ling. 3001 or consent of department.

Methodology for phonological analysis of language, examination of phonological data from hypothetical and natural languages. Collateral readings, problems.

Ling. 3003. Introduction to Structural Linguistics II

3-0-3. Prerequisite: Ling. 3002 or consent of department.

Continuation of Ling. 3002 with emphasis on morphology and syntax, study of the works of Bloomfield, Pike and Harris. Collateral readings, problems.

Ling. 4001. History of Linguistics

3-0-3. Prerequisite: prior study of linguistics or consent of department.

Survey of the theoretical developments in linguistic science with major emphasis on the developments of the nineteenth and early twentieth centuries.

Ling. 4002. Current Developments in Linguistics

3-0-3. Prerequisite: prior study of linguistics or consent of department.

Live issues in the field and approaches favored by various contemporary schools.

Ling. 4003. Semantics and Linguistic Structure

3-0-3. Prerequisite: prior study of linguistics or consent of department.

Various approaches to the problem of dealing with meaning in linguistic analysis.

Ling. 4021. Contrastive Language Systems

3-0-3. Prerequisite: Ling. 3001-2-3 or consent of department.

A comparison of the similarities and differences of selected major languages with English in respect to phonology, written representation, syntactic and semantic categories.

Ling. 4075-6-7. Comparative Analysis of Major European Languages I, II, III

3-0-3 each. Prerequisite: junior standing or consent of department.

Emphasis on grammatical and semantical structures and their correspondences. English as the control language. Ling. 4075 treats the major Slavic languages. Ling. 4076 treats the major Germanic languages. Ling. 4077 treats the major Romance languages.

Ling. 4901-2-3-4. Special Problems in Linguistics

Credit to be arranged.

Provides the special instruction required under special programs.

Russian

Russ. 1001. Elementary Russian

3-2-4. Prerequisite: two years of high school training in any foreign language or equivalent or consent of department.

Pronunciation, essential principles of Russian grammar, acquisition of vocabulary through illustrative readings, intensive familiarization with recorded material.

Russ. 1002. Elementary Russian

3-2-4. Prerequisite: Russ. 1001 or equivalent.

Continuation of Russ. 1001, introduction of additional reading material as progress of class permits.

Russ. 1003. Elementary Russian

3-2-4. Prerequisite: Russ. 1002 or equivalent.

Continuation of Russ. 1002, emphasis on the reading of simple prose.

Russ. 2001. History and Culture of Russia I

3-0-3. Prerequisite: Russ. 1003 or equivalent.

Period: Ninth century to eighteenth. Review of grammar and oral practice.

Russ. 2002. History and Culture of Russia II

3-0-3. Prerequisite: Russ. 2001 or equivalent.

Period: Eighteenth century to 1917. Review of grammar and oral practice.

Russ. 2003. History and Culture of Russia III

3-0-3. Prerequisite: Russ. 2002 or equivalent.

Period: 1917 to the present. Review of grammar and oral practice.

Russ. 3001. Period: 1800–1860. Romanticism, The Golden Age of Russian Poetry, Naturalism

3-0-3. Prerequisite: Russ. 2003 or equivalent.

Readings in Russian.

Russ. 3002. Period: 1860–1900. The Golden Age of Russian Prose, Realism

3-0-3. Prerequisite: Russ. 2003 or equivalent.

Readings in Russian.

Russ. 3003. Period: 1900 to the Present. Symbolism, Futurism, Soviet Literature

3-0-3. Prerequisite: Russ. 2003 or equivalent.

Readings in Russian.

Russ. 4075. Intensive Readings in Russian I

3-0-3. Prerequisite: normally taken by students of at least junior standing or consent of department.

Acquisition in one quarter of as much Russian as is normally ac-

quired in two. Aim: development of linguistic competence for reading and comprehension.

Russ. 4076. Intensive Readings in Russian II

3-0-3. Prerequisite: Russ. 4075.

Continuation of Russ. 4075, with comparable achievement as objective.

Russ. 4077. Intensive Readings in Russian III

3-0-3. Prerequisite: Russ. 4076.

Continuation of Russ. 4076, with comparable achievement as objective.

Russ. 4901-2-3-4. Special Problems in Russian

Credit to be arranged.

Provides the special instruction required under special programs.

Spanish

Span. 1001. Elementary Spanish

3-0-3.

Pronunciation, grammar, reading, composition, simple conversational exercises.

Span. 1002. Elementary Spanish

3-0-3. Prerequisite: Span. 1001 or equivalent.

Continuation of Span. 1001, increased emphasis on reading and conversation.

Span. 1003. Elementary Spanish

3-0-3. Prerequisite: Span. 1002 or equivalent.

Continuation of Span. 1002, completion of fundamentals of Spanish grammar.

Span. 2001. Cultural History of Spain I

3-0-3. Prerequisite: Span. 1003 or equivalent.

Period: prehistoric times through the Middle Ages.

Span. 2002. Cultural History of Spain II

3-0-3. Prerequisite: Span. 2001 or equivalent.

Period: 1450–1700.

Span. 2003. Cultural History of Spain III

3-0-3. Prerequisite: Span. 2002 or equivalent.

Period: 1700 to the present.

Span. 3001. Spanish-American Literature Before 1895

3-0-3. Prerequisite: Span. 2003 or equivalent.

Conducted in Spanish.

Span. 3002. Spanish-American Literature Since 1895

3-0-3. Prerequisite: Span. 2003 or equivalent.

Conducted in Spanish.

Span. 3003. Introduction to Spanish Literature

3-0-3. Prerequisite: Span. 2003 or equivalent.

The cultural heritage of Spain in the Americas as reflected in representative European and Spanish-American literary works. Conducted in Spanish.

Span. 3004. Cultural History of Mexico

3-0-3. Prerequisite: Span. 2003 or equivalent.

Readings from representative authors. Vocabulary building, lectures, discussions, conversation and composition.

Span. 3005. Contemporary Latin America

3-0-3. Prerequisite: Span. 2003 or equivalent.

Selected contemporary essays, speeches and diverse documents reflecting social, economic and political problems. Conducted in Spanish.

Span. 3006. Stylistics

3-0-3. Prerequisite: Span. 2003 or equivalent.

Grammar review through conversational drills in language laboratory, composition.

Span. 3007-8-9. Cultural History of Spain

3-0-3 each. Prerequisite: native or near-native fluency in Spanish.

Spanish civilization from prehistoric times to the present. Readings in representative authors. All courses conducted in Spanish.

Span. 4001. Spanish Drama Before 1700

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on Lope de Vega and Calderon. Conducted in Spanish.

Span. 4002. Spanish Drama Since 1700

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on Lorca and Casona. Conducted in Spanish.

Span. 4003. Spanish Prose Before 1700

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on the *Celestina*. Conducted in Spanish.

Span. 4004. Spanish Prose Since 1700

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on works of the generation of 1898. Conducted in Spanish.

Span. 4007. Spanish Historical Linguistics

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on phonology and morphology treated descriptively and comparatively. Brief survey of the historical development of the Spanish language. Conducted in Spanish.

Span. 4008. *Libro de buen amor*

3-0-3. Prerequisite: Span. 4007 or equivalent.

Detailed linguistic and literary analysis of the Ruiz masterpiece as the vortex of Spanish medieval literature. Conducted in Spanish.

Span. 4009. *Don Quixote*, Part I

3-0-3. Prerequisite: Span. 3006 or equivalent.

Detailed study of Cervantes' masterpiece as the vortex of Spanish literature, the prototype of the modern novel and the essence of Renaissance and Baroque literature. Conducted in Spanish.

Span. 4010. *Don Quixote*, Part II

3-0-3. Prerequisite: Span. 3006 or equivalent.

Continuation of Span. 4009.

Span. 4075. Intensive Readings in Spanish I

3-0-3. Prerequisite: normally taken by students of at least junior standing.

Acquisition in one quarter of as much Spanish as is normally acquired in two. Aim: development of linguistic competence for reading and comprehension.

Span. 4076. Intensive Readings in Spanish II

3-0-3. Prerequisite: Span. 4075.

Continuation of Span. 4075, with comparable achievement as objective.

Span. 4077. Intensive Readings in Spanish III

3-0-3. Prerequisite: Span. 4076.

Continuation of Span. 4076, with comparable achievement as objective.

Span. 4091-2-3. Spanish Study Abroad

5-0-5 each.

The Study Abroad Program of the University System of Georgia. Fifteen quarter hours credit for summer study abroad.

Span. 4901-2-3-4. Special Problems in Spanish

Credit to be arranged.

Provides the special instruction required under special programs.

Music

Music 2001. Choral Music—History

1-2-1. Sophomore, junior or senior year, fall quarter. Prerequisite: satisfactory completion of three quarters in Glee Club, consent of department.

Practical and laboratory work, rehearsing and performing choral music, history and development of choral music from Gregorian chant through Palestrina and Bach to the present.

Music 2002. Choral Music—Conducting

1-2-1. Sophomore, junior or senior year, winter quarter. Prerequisite: satisfactory completion of three quarters in Glee Club, consent of department.

Rehearsal or performance of choral music, practice conducting by the students.

E.E. 6072. Fourier Optics and Holography

3-0-3. Prerequisite: E.E. 6071 or consent of school.

Principles of diffraction, lenses, coherent and incoherent imaging, optical information processing and holography presented in a linear invariant systems framework.

E.E. 6081. Information Theory

3-0-3. Prerequisite: E.E. 6050.

Introduction to information theory. The concepts of information, information rate and channel capacity are developed and applied to communication theory problems. Rate-distortion theory is introduced.

E.E. 6082. Coding

3-0-3. Prerequisite: E.E. 6050.

Coding techniques for efficient, reliable communication are introduced. Techniques studied include parity-check, maximal-length, hamming, BCH and convolutional codes, sequential decoding and coding for burst-noise channels.

E.E. 6091. Radar Engineering

3-0-3. Prerequisite: E.E. 6131, 6061.

Statistical decision and estimation theory as applied to radar situations. Slowly fluctuating point targets, singly and doubly spread targets, accuracy, ambiguity and resolution. Performance bounds.

E.E. 6092. Computer Communication Systems

3-0-3. Prerequisite: graduate standing.

Provides information necessary for the design or analysis of computer-to-computer data transmission systems.

E.E. 6100. Linear Networks and Systems

3-0-3. Prerequisite: graduate standing.

Introduction to a rigorous treatment of linear systems theory. Topics include theory of vector spaces, linear transformations, state variables, linear dynamical systems, controllability and observability.

E.E. 6101. Time Varying and Nonlinear Systems

3-0-3. Prerequisite: E.E. 6100.

Analysis and design of engineering systems with time varying and/or nonlinear characteristics. Systems representation and properties of the presentation. Linearization techniques. Stability analysis using Liapunov and Popov's theories.

E.E. 6111. Feedback Control Systems

3-0-3. Prerequisite: E.E. 6100.

Optimal control approach to control system design. Formulation of optimal control problems using state-space approach, dynamic programming, calculus of variations and maximum principle.

E.E. 6112. Feedback Control Systems

3-0-3. Prerequisites: E.E. 6101, 6111 or consent of school.

Design techniques for linear, nonlinear automatic control systems. Synthesis of linear systems, closed loop response and performance. Minimum time, fuel and error design.

E.E. 6113. Feedback Control Systems

3-0-3. Prerequisite: E.E. 6100.

Application of discrete time control to continuous systems. Time and frequency domain analysis of sampled data systems.

E.E. 6131. Optimum Linear Filters
3-0-3. Prerequisite: E.E. 6051, 6101 or consent of school.

Linear filtering theory, both classical and modern approaches. Applications in communication and control. Particular emphasis on Wiener-Hopf filter and Kalman filter.

E.E. 6152. Computer Simulation
3-0-3. Prerequisite: graduate standing or consent of school and elementary programming ability.

A study of computational methods for use in the digital simulation of deterministic systems. Several simulation projects are a part of the course.

E.E. 6153. Computer Simulation
3-0-3. Prerequisite: E.E. 6050 or consent of school and elementary programming ability.

Nondeterministic systems — a study of problems associated with generating and analyzing random time series using digital computers. Spectral estimation and statistical inference are among topics covered.

E.E. 6161. Digital Systems Engineering I
3-0-3. Prerequisite: graduate standing.

Functional organization and sequential operations of digital computers. Number representation, digital arithmetic, computer elements, micro-operations and sequences for instruction execution and control and command logic.

E.E. 6162. Digital Systems Engineering II
3-0-3. Prerequisite: graduate standing.

Concepts, technology related to microprogramming. Comparison

of sequential hardware control and microprogrammed control. Design parameters, tradeoffs for control memory, control word structures. Evaluation of several microprogrammable systems. Future impact.

E.E. 6163. Digital Systems Engineering III
3-0-3. Prerequisite: graduate standing.

Assembly language programming. The "MIX" machine simulated on the U-1108. Programming problems in "MIX." Advanced programming techniques. Information structures, dynamic storage allocation.

E.E. 6201. Automata Theory
3-0-3. Prerequisite: graduate standing.

An introduction to broad classes of digital systems including computer components as special cases. A detailed study is made of steps leading to optimum design.

E.E. 6202. Automata Theory
3-0-3. Prerequisite: E.E. 6201.

A continuation of digital system study including fault detection and decomposition of systems. Reliability, memory span and quadded logic are also examined.

E.E. 6203. Automata Theory
3-0-3. Prerequisite: E.E. 6202 or consent of school.

An introduction to finite automata through study of sequential circuits. Concepts in modern algebra are developed for direct application to sequential circuits.

E.E. 6211. Digital Systems Engineering Laboratory
0-3-1. Prerequisite: E.E. 6161 or equivalent.

Digital computer engineering. Registers, transfer level logic

devices, hardwired structures, microprogrammed structures, memory, input-output.

E.E. 6251. Applied Electromagnetics

3-0-3. Prerequisite: graduate standing or consent of school.

Advanced electromagnetic theory. Particular and complementary solutions to the symmetric wave equations for both the discrete and continuous cases. Analysis, synthesis and boundary value problems.

E.E. 6252. Microwaves

3-0-3. Prerequisite: E.E. 6251.

Field analysis of guided waves. Equivalent-circuit theory for microwave systems. Broadband impedance matching. Passive microwave devices. Microwave cavities. Periodic structures and filters.

E.E. 6253. Antennas

3-0-3. Prerequisite: E.E. 6251.

Classical antenna theory. The antenna as a receiver. Uniform and non-uniform arrays. Pattern synthesis. Cylindrical antennas and arrays. Slot antennas, horns and reflector antennas.

E.E. 6301. Electro-optics

3-0-3. Prerequisite: graduate standing.

Introduction to electro-optics with emphasis on lasers and modern optics. Parametric interactions, Kerr and Pockels effect, harmonic generation. Applications include communications, data processing.

E.E. 6351. Advanced Electrical Measurements

3-3-4. Prerequisite: graduate standing.

Theory of measurement and

practical application of instrumentation. Measurement uncertainties, system modeling, component parts of system accuracy, data accumulation, reduction and interpretation are considered.

E.E. 6361. Integrated Circuits

3-0-3. Prerequisite: graduate standing.

Design, fabrication and application considerations of monolithic ICs. Analysis of the unconventional circuitry contained in typical integrated circuits. Applications of available logic lines and linear ICs.

E.E. 6401. Advanced Network Theory

3-3-4. Prerequisite: graduate standing.

Special techniques of network analysis that are not usually covered in undergraduate curricula. Topics include networks involving active elements, multiport or multiterminal elements, pathological elements.

E.E. 6402. Advanced Network Theory

3-3-4. Prerequisite: graduate standing.

A survey of various techniques of passive analog filter design. The objective is to enable the student to design practical filters with understanding of underlying principles.

E.E. 6403. Advanced Network Theory

3-3-4. Prerequisite: graduate standing.

Techniques of synthesizing networks using active elements such as gyrators, controlled sources, immittance transducers, operational amplifiers. Practical filter design using these elements.

E.E. 6411. Distributed-Parameter Networks

3-0-3. Prerequisite: graduate standing.

Analysis and synthesis of distributed-parameter networks. Uniform and nonuniform lossy and lossless transmission lines. Application of these networks in integrated circuits is also considered.

E.E. 6412. Time-domain Synthesis of Linear Networks

3-0-3. Prerequisite: graduate standing.

Methods of specifying a network function to give a prescribed time-domain response. Mathematical techniques suitable for obtaining the time-domain approximating functions.

E.E. 6413. Digital Filters

3-0-3. Prerequisite: graduate standing or consent of school.

Unified theory of digital processing of signal and spectrum analysis. Digital filter design and applicable analog filter review. Discrete Fourier transforms including fast Fourier transform.

E.E. 6421. Advanced Network Theory II

3-0-3. Prerequisite: graduate standing or consent of school.

An introduction to applied combinatorics including combinations, permutations, recursion, partition, generating functions, inclusion and exclusion, rook polynomials and Polya's theorem.

E.E. 6422. Advanced Network Theory II

3-0-3. Prerequisite: graduate standing.

Topological analysis of networks. Current interest topics presented from a linear-graph

aspect. Concepts and techniques of network and system analysis by topological methods.

E.E. 6423. Advanced Network Theory II

3-0-3. Prerequisite: consent of school.

Specialized topics of current interest in network theory.

E.E. 6451. Electrical Properties of Materials

3-0-3. Prerequisite: graduate standing or consent of school.

Basis of quantum mechanical formalism and modeling to serve as an introduction to the modern study of electrical properties of materials.

E.E. 6452. Magnetic and Dielectric Properties of Materials

3-0-3. Prerequisite: E.E. 6451 or consent of school.

Dielectrics, piezo- and ferroelectrics and their application to electromechanical devices. Quantum basis of magnetism. Magnetic interactions, domains, resonance and devices.

E.E. 6453. Solid-state Electronic Devices

3-0-3. Prerequisite: graduate standing or consent of school.

Study of charge and energy transport in semiconductors with applications in pn junction, interface and thin film, optoelectronic and bulk-effect devices.

E.E. 6461. Modern Magnetic Materials and Devices

3-0-3. Prerequisite: E.E. 6452 or consent of school.

Basic operation and design of magnetic memories and microwave devices. Crystal structure, chemical composition. Properties of ferrites, garnets and orthoferrites.

E.E. 6500. Introduction to Management and Control of Energy Systems

3-0-3. Prerequisite: E.E. 6100 or consent of school.

Fundamentals of static as well as dynamic system theory as applied to typical energy engineering problems. Optimization theory, decision analysis techniques for large-scale systems.

E.E. 6501. Planning of Power Systems

3-0-3. Prerequisite: E.E. 4019, 6050 or consent of school.

An introduction to planning procedures for large scale technical operations. Technical and economic constraints on planning. Techniques for formulation of rational planning problems.

E.E. 6502. Control and Operation of Interconnected Power Systems

3-0-3. Prerequisite: E.E. 4019, 6100 or consent of school.

Operation of interconnected systems. Models for system interaction, techniques for control and management of power flow and reliability.

E.E. 6503. Evaluation of Power System Reliability

3-0-3. Prerequisite: E.E. 4019, 6050 or consent of school.

Techniques for the study of power system reliability. Probabilistic models for power system performance. Techniques for subsystem and composite system reliability analysis.

E.E. 6511. Transmission Lines

3-3-4. Prerequisite: graduate standing.

A study of electric power transmission parameters, models and techniques for analysis of

steady state and transient conditions. A-c, d-c, HV and underground transmission.

E.E. 6521. Power System Stability

3-0-3. Prerequisite: E.E. 4019, 6100.

Static and dynamic stability, generator swing equation. Techniques for stability analysis. Voltage and frequency control.

E.E. 6750. Systems Design Methodology

2-3-3. Prerequisite: graduate standing or consent of school.

An introduction to complex system design, interdisciplinary. Also taught as A.E. 6750, M.E. 6750.

E.E. 6751-2. Complex System Design

2-4-3 each. Prerequisite: graduate standing or consent of school.

The class acts as an interdisciplinary team to carry out a significant relevant preliminary design of a complex system. Also taught as A.E. 6751-2, M.E. 6751-2.

E.E. 6760. Atomic Collisions

3-0-3. Prerequisite: graduate standing in science or engineering.

A discussion of the techniques by which atomic collisions phenomena are studied, includes scattering of ions and electrons in gases and scattering from solid surfaces. Also taught in the School of Physics.

E.E. 6988. Noise in Communications Systems

3-0-3. Prerequisite: E.E. 6062.

Basic binary and m-ary digital signaling techniques are studied, with emphasis on the effects of noise in these systems.

E.E. 6989. Introduction to Plasma Dynamics

3-0-3. Prerequisite: E.E. 6451.

The theoretical study of plasma dynamics. Considers charged particle orbits in electric and magnetic fields, space charge, current sheaths and electromagnetic waves in ionized gases.

E.E. 6990. Plasma Diagnostics

3-3-4. Prerequisite: E.E. 6989.

Diagnostic techniques applicable to determining properties of plasmas. Topics include macroscopic measurements, electric and magnetic probes, optical and microwave techniques. Selected laboratory experiments.

E.E. 6991. Hydromagnetics

3-0-3. Prerequisite: E.E. 6989.

The theoretical study of the motion of conducting fluids in magnetic fields. Natural hydromagnetic phenomena. Engineering applications.

E.E. 7000. Master's Thesis**E.E. 7051-2-3. Advanced Communication Theory**

3-0-3 each. Prerequisite: E.E. 6051, 6062.

Latest developments in communications are treated in lecture and seminar. Emphasis on current literature and open research areas.

E.E. 7101-2-3. Advanced Feedback Control Theory

3-0-3 each. Prerequisite: consent of school.

Advanced techniques for analysis and design of automatic control systems.

E.E. 7251-2-3. Advanced Electromagnetic Theory

3-3-4 each. Prerequisite: E.E. 6251 or consent of school.

Topics of fundamental importance in electromagnetics. Advanced developments in the fields of antennas, propagation, and microwave theory and practice.

E.E. 7999. Preparation for Doctoral Qualifying Exams

Non-credit.

Preliminary doctoral examination. Spring quarter.

E.E. 8001-2-3. Seminar

1-0-1 each.

E.E. 8011-2-3. Seminar

1-0-0 each.

E.E. 8140 through 8149. Special Topics

1-0-1 each.

Special topics of unusual current interest: introductory treatments of new developments in electrical engineering.

E.E. 8240 through 8249. Special Topics

2-0-2 each.

E.E. 8340 through 8349. Special Topics

3-0-3 each.

E.E. 8430 through 8439. Special Topics

4-0-4 each.

E.E. 8440 through 8449. Special Topics

5-0-5 each.

E.E. 8500 through 8998. Special Problems

Credit to be arranged.

Problems meeting the special problems of the student. Approval to schedule must be obtained in advance of registration.

E.E. 9000. Doctoral Thesis

Engineering Science and Mechanics

E.S.M. 1101. Introduction to Engineering 2-3-3.

The engineer and design, relation between the student's curriculum and his career in engineering. Emphasis placed on student participation in creative design process.

Text: at the level of Beakley and Leach, *Engineering: An Introduction to a Creative Profession*.

E.S.M. 1750. Introduction to Bio-Engineering 3-0-3.

Bio-engineering aspects of human body including its mechanics, nervous system control, material properties and biological fluid flows. Diagnostic techniques and assisting and replacement prosthetic devices. Also listed as A.E. 1750, E.E. 1750, M.E. 1750.

E.S.M. 1901 through 1909. Special Problems in Engineering Science 3-0-3, maximum. Prerequisite: freshman standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty advisor.

E.S.M. 2101. Engineering Design I 0-3-1. Prerequisite: E.S.M. 1101 or consent of department

Study of a problem that arises from a need of society. Proposals for a creative solution studied to select best design.

E.S.M. 2102. Engineering Design II

0-6-2. Prerequisite: E.S.M. 2101.
Continuation of E.S.M. 2101.

Design of problem to be completed, a model to be submitted as part of final report.

E.S.M. 2201. Statics

3-0-3. Prerequisite: Phys. 2121. Prerequisite or corequisite: Math. 2307.

Elements of statics in two- and three-dimensions, centroids, analysis of structures and machines, friction.

Text: at the level of Beer and Johnston, *Vector Mechanics for Engineers: Statics*, or Lnenicka, Bernard and Stoneking, *Programmed Statics*.

E.S.M. 2901 through 2909. Special Problems in Engineering Science 3-0-3, maximum. Prerequisite: sophomore standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty advisor.

E.S.M. 3111. Experimental Methods in Engineering Science 2-3-3. Prerequisite: E.E. 3400, Math. 2309, E.S.M. 3201, 3301.

Methods used to observe behavior of physical parameters in engineering problems, photo-optics, signal analysis, transducers and transducer circuits, models and analogies.

Text: at the level of Tuve and Domholdt, *Engineering Instrumentation*.

E.S.M. 3201. Dynamics I

3-0-3. Prerequisite: E.S.M. 2201, Math. 2307.

Kinematics and kinetics of rigid bodies in plane motion.

Text: at the level of Beer and Johnston, *Vector Mechanics for Engineers: Dynamics*.

E.S.M. 3202. Dynamics II

3-0-3. Prerequisite: E.S.M. 3201.

Kinematics and kinetics of three-dimensional motion of rigid bodies.

Text: at the level of Beer and Johnston, *Vector Mechanics for Engineers: Dynamics*.

E.S.M. 3301. Mechanics of Deformable Bodies

5-0-5. Prerequisite or corequisite: E.S.M. 2201, Math. 2308.

Definition and analysis of strain and stress, applications to axially loaded elements, torsion of circular shafts and bending of beams, introduction to simple plasticity and to column stability.

Text: at the level of Popov, *Introduction to the Mechanics of Solids*.

E.S.M. 3302. Mechanics of Materials

3-0-3. Prerequisite: E.S.M. 3301.

Analysis and design of beams (using singularity functions), various structural elements (using energy methods), thick-walled cylinders, rotating disks, curved beams. Theories of failure.

E.S.M. 3451. Computer Applications in Engineering Science and Mechanics

2-3-3. Prerequisite or corequisite: E.S.M. 3302, 4210, 3501 or consent of department.

Introduction to the use of the digital computer, Fortran languages, computer solutions of problems in statics, dynamics, mechanics of deformable solids, vibrations and fluid mechanics.

E.S.M. 3501. Fluid Mechanics

5-0-5. Prerequisite: E.S.M. 3302. Prerequisite or corequisite: Math 2308.

Kinematics of fluid motion, material and spatial coordinates,

acceleration, continuity, vorticity, perfect fluid motion, introduction to the motion of a viscous fluid.

Text: at the level of Owczarek, *Introduction to Fluid Mechanics*.

E.S.M. 3701. Statics

3-0-3. Prerequisite: Arch. 2301, Math. 1309, Phys. 2111.

Elements of coplanar statics, particle and rigid body equilibrium, centroids, centers of gravity, distributed loads, analysis of structures and beams, shear and bending moment.

Text: at the level of Beer and Johnston, *Mechanics for Engineers: Statics*.

E.S.M. 3702. Mechanics of Materials

3-0-3. Prerequisite: E.S.M. 3701.

Simple stresses and strains, mechanical properties of materials, Hooke's Law, moments of inertia of areas, analysis and design of beams and columns, deflection of beams.

Text: at the level of Popov, *Mechanics of Materials*.

E.S.M. 3711. Dynamics

5-0-5. Prerequisite: E.S.M. 2201.

Kinematics of particles and rigid bodies, kinetics of translation, rotation and plane motion, work and energy relations.

Text: at the level of Work, *A Programmed Instruction in Dynamics*.

E.S.M. 3901 through 3909. Special Problems in Engineering Science

Credit to be arranged. Prerequisite: junior standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty adviser.

E.S.M. 4111. Introduction to Experimental Stress Analysis

1-6-3. Prerequisite: E.S.M. 3301 or equivalent, senior standing.

Plane stress analysis using transmitted light photoelasticity and photoelastic models, study of surface strain using resistance strain gages, transducer design and application.

Text: at the level of Holister, *Experimental Stress Analysis*.

E.S.M. 4121. Projects in Engineering Science

3-0-3. Prerequisite: consent of department.

Experimental and/or theoretical investigation of an engineering problem, individual student effort with faculty project advisor, written report.

E.S.M. 4201. Intermediate Dynamics I

3-0-3. Prerequisite: E.S.M. 3202 or consent of department.

Kinematics and kinetics of particles and particle systems, applications include motion in resisting medium, redistribution of mass, central force motion, effects of earth rotation.

Text: at the level of Marris and Stoneking, *Advanced Dynamics*.

E.S.M. 4202. Intermediate Dynamics II

3-0-3. Prerequisite: E.S.M. 4201 or consent of department.

Two- and three-dimensional motion of a rigid body, Euler's equations, introduction to energy methods and Lagrange's equations.

E.S.M. 4210. Mechanical Vibrations I

3-0-3. Prerequisite: E.S.M. 3201, E.S.M. 3301 and Math. 2309 or their equivalent.

Single degree-of-freedom

system, two degrees-of-freedom system and finitely many degrees-of-freedom system complex representation, applications.

Text: at the level of Thomson, *Vibration Theory and Applications*.

E.S.M. 4211. Mechanical Vibrations II

3-0-3. Prerequisite: E.S.M. 4210 and E.S.M. 3302 or equivalent. Fall quarter.

Complex representation, step and impulse loads, many degrees of freedom, influence coefficients, matrix methods, stability of solution, vibrations of strings, beams and membranes, approximate methods.

Text: at the level of Thomson, *Vibration Theory and Applications*.

E.S.M. 4301. Mechanics of Deformable Bodies

3-0-3. Prerequisite: E.S.M. 3301.

Small strain linear elasticity in two- and three-dimensions, applications in generalized plane stress and plane strain, torsion and bending of non-circular prisms.

E.S.M. 4302. Stress Analysis

3-3-4. Prerequisite: E.S.M. 4301.

Continuation of E.S.M. 4301, further treatment of torsion and bending, strain energy, introduction to thin plates and simple shells, approximation methods.

E.S.M. 4351. Continuum Mechanics

3-0-3. Prerequisite: Math. 2309, E.S.M. 3301.

Geometrical foundations, analysis of stress and deformation, balance laws, constitutive equations, finite and infinitesimal elasticity.

E.S.M. 4401. Materials Science

3-0-3. Prerequisite: senior standing.

Introduction to fatigue, creep, effect of shape, size, temperature and microstructure of specimen, more common stress-strain equations, hysteresis, after effect, etc., theories of failure.

Text: at the level of Cottrell, *The Mechanical Properties of Matter*.

E.S.M. 4451. Biomechanics

3-0-3. Prerequisite: Math. 4582 or equivalent, E.S.M. 3501 or equivalent.

Mechanical modeling of human body, muscle mechanics, steady non-Newtonian flows, material properties of human body, hemodynamics, anomalies of blood, wave propagation in arteries.

E.S.M. 4801 through 4809. Special Topics in Engineering Science

1-0-1 through 9-0-9, respectively. Prerequisite: senior standing.

Special courses not included in regular course offerings.

E.S.M. 4901 through 4909. Special Problems in Engineering Science

Credit to be arranged. Prerequisite: senior standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty adviser.

E.S.M. 6111. Theory of Experimental Stress Analysis

2-3-3. Prerequisite: E.S.M. 6341 or consent of department. Spring quarter.

Study of surface stress and strain using brittle coatings and electrical resistance strain gages, strain gage circuits, static and dynamic problems, transducer design and circuits.

E.S.M. 6115. Introductory Photoelasticity

1-6-3. Prerequisite: E.S.M. 6341 or

consent of department. Fall quarter.

Polarized light, mathematical description and light transformations, solution of plane stress problems using transmitted light, separation of principal stresses, photoelastic models.

E.S.M. 6116. Photoelasticity

1-6-3. Prerequisite: E.S.M. 6115. Winter quarter.

Three-dimensional stress analysis using transmitted light and scattered light methods, birefringent coatings, Moire fringes, numerical methods.

E.S.M. 6201. Advanced Dynamics I

3-0-3. Prerequisite: E.S.M. 4210 and Math. 2309, or equivalent. Fall quarter.

Kinematics and kinetics of particles, angular velocity, inertia properties, rigid body dynamics, generalized coordinates and forces, nonholonomic systems, solutions by vector methods and Lagrange's equations.

E.S.M. 6202. Advanced Dynamics II

3-0-3. Prerequisite: E.S.M. 4202 or 6201. Winter quarter.

A continuation of E.S.M. 6201. Hamilton's principle, Hamilton's canonical equations, energy and momentum integrals, Hamilton-Jacobi theory, study of selected papers from recent dynamics literature.

E.S.M. 6221. Theory of Oscillations

3-0-3. Prerequisite: Math. 4582 or consent of department. Fall quarter.

Lagrange's equations, normal modes, orthogonality, dynamic coupling, small oscillations of conservative systems, non-conservative systems, vibrations of flexible strings and elastic bars.

N.E. 8001-2-3. Seminar
1-0-0 each.

Regularly scheduled, noncredit course required of all N.E. majors. Various topics presented by graduate students, faculty members and guest speakers.

N.E. 8110-1-2-3. Special Topics
Credit to be arranged. Prerequisite: consent of school.

Purpose of this course is to permit the School of Nuclear Engineering to offer formal courses on topics of special interest on an ad hoc basis.

N.E. 8501-2-3-4. Special Problems
Credit to be arranged. Prerequisite: consent of school.

The student is encouraged to exercise his resourcefulness and originality in attacking a problem of special interest to himself and a member of the N.E. faculty.

N.E. 8999. Doctoral Thesis Preparation

N.E. 9000. Doctoral Thesis

Physical Education And Recreation

P.E. 1010. Swimming
0-4-1.

Each student strives for maximum safety by thoughtful experimentation with simulated water emergencies. Drownproofing evolves as the basic method for survival.

P.E. 1020. Physical Fitness and Gymnastics
0-4-1.

Gymnastic movement is the medium through which students develop and learn to maintain essential elements of fitness in-

cluding flexibility, coordination, strength, balance and kinesthetic awareness.

P.E. 1030. Women's Gymnastics
0-4-1.

Instruction, demonstration and practice of basic and intermediate women's gymnastics skills utilizing the four olympic women's events plus the trampoline. Flexibility and general physical conditioning exercises will be included.

P.E. 1040. Health Education
3-0-3.

Guest lecturers from the medical profession acquaint the student with contemporary personal health problems including drugs, nutrition, emotional health and sex education.

P.E. 1050. Aerobic Conditioning
0-4-1.

Primary emphasis is placed on the improvement of endurance and of cardiovascular and respiratory system efficiency through an individually tailored program of jogging and recreational sports.

P.E. 2040. Softball
0-4-1.

Basic fundamentals will be demonstrated and practiced. Teams will be organized for competition.

P.E. 2050. Tennis
0-4-1.

Demonstration and lecture on fundamentals of the game, followed by practice of essential skills. Singles, doubles and mixed doubles tournaments will be organized.

P.E. 2060. Volleyball
0-4-1.

The serve, spiking, passing, team defensive and offensive play

will be demonstrated and practiced after which team competition is organized.

P.E. 2070. Paddleball

0-4-1.

Scoring, defensive and offensive strategy along with basic fundamentals of the serve and volley will be demonstrated and practiced. Singles and doubles competition will be organized.

P.E. 2080. Bowling

0-4-1.

Team and league bowling competition follows a comprehensive instructional program utilizing both live and filmed demonstration of basic skills and techniques.

P.E. 2090. Advanced Physical Conditioning

0-4-1.

An individually tailored physical fitness program with emphasis on proper techniques of weight training. Total body development is stressed, with flexibility and aerobic conditioning included.

P.E. 2100. Fencing

0-4-1.

Demonstration and practice of fencing fundamentals and rules with the French foil as the weapon. Practice bouting and officiating will follow partial mastery of these skills.

P.E. 2110. Basketball

0-4-1.

The basic fundamentals of the game will be practiced. Team competition will then be organized.

P.E. 2120. Touch Football

0-4-1.

Game rules and team strategy will be covered, followed by competition.

P.E. 2130. Soccer

0-4-1.

Organization of teams and competition follows skills practice and demonstration of offensive and defensive strategy. Position assignments, safety and game rules discussed.

P.E. 2140. Athletic Officiating

2-2-1.

Study of rules with laboratory experience. Instruction, demonstration and practical application of mechanics of officiating athletic games. Will help meet entrance requirements for professional officiating.

P.E. 2150. Senior Lifesaving

0-4-1.

Instruction, demonstration and practice of carries, approaches and releases utilized in rescuing victims.

P.E. 2160. Water Safety Instructor Course

1-3-2. Prerequisite: senior lifesaving certificate.

Acquisition of motor skills and the mastery of methods of teaching lifesaving and swimming courses. Instruction in other aquatic activities such as pool operations, pool management, lifeguarding and swimming and diving coaching.

Physics

Phys. 1000. Physics Orientation

1-0-1.

Guest lectures will describe career opportunities in physics, the role physicists play in government and industrial laboratories and in education and programs available to physics major.

Phys. 2010. Physics of the Weather
3-0-3.

An introductory treatment of the application of the basic physical laws to the understanding of weather phenomena. The main weather features will be descriptively developed.

Text: at the level of Riehl, *Introduction to the Atmosphere*.

Phys. 2021. Introduction to Astronomy I
3-0-3.

The nature and behavior of the earth and the other members of the solar system will be examined.

Text: at the level of Abell, *Exploration of the Universe*.

Phys. 2022. Introduction to Astronomy II
3-0-3. Prerequisite: Phys. 2021 or consent of the department.

The nature and behavior of the stars and galaxies will be examined.

Text: at the level of Abell, *Exploration of the Universe*.

Phys. 2111-2-3. Elementary College Physics
4-0-4 each. Courses should be taken in sequence.

Basic study of the physical principles of mechanics, sound heat electricity, light and modern physics for students in the less technical curricula. Method of teaching and subject matter chosen to give an understanding of scientific methods and a background of scientific information needed to comprehend the commercial, cultural and political significance of scientific progress.

Text: at the level of Bueche, *Principles of Physics*.

Phys. 2121. Particle Dynamics
4-3-5. Corequisite: Math. 1309.

Introduction to classical

mechanics. Topics include kinematics, dynamics, energy, momentum and rotational motion. Laboratory based on frictionless surfaces and stroboscopic photographic equipment emphasizes data analysis.

Text: at the level of Halliday and Resnick, *Fundamentals of Physics*.

Phys. 2122. Electromagnetism
4-3-5. Prerequisite: Phys. 2121, Math. 1309.

Topics include electric field, potential, magnetic field and electromagnetic induction. Calculus and vectors are used. The laboratory stresses use of electrical instruments including oscilloscopes.

Text: at the level of Halliday and Resnick, *Fundamentals of Physics*.

Phys. 2123. Optics and Modern Physics
4-3-5. Prerequisite: Phys. 2122 and Math. 1309.

Wave propagation, interference, diffraction and polarization. Geometrical optics. Particle aspects of electromagnetic radiation and wave aspects of material particles. Bohr model. Laboratory illustrates wave propagation.

Text: at the level of Halliday and Resnick, *Fundamentals of Physics*.

Text: at the level of Halliday and Resnick, *Fundamentals of Physics*.

Phys. 2141-2-3. General Physics
5-3-6 each. Corequisite: Math. 1309, courses to be taken in sequence.

The sequence parallels Phys. 2121-2-3; courses from the two sequences may be intermixed. In this sequence some topics will be treated in more depth and some additional topics will be included. These courses are intended for students with demonstrated competence in mathematics and who desire a more rigorous foundation in physics.

Text: at the level of Halliday and Resnick, *Fundamentals of Physics*.

Text: at the level of Resnick and Halliday, *Physics*.

Phys. 3001. Introductory Modern Physics

5-0-5. Prerequisite: Phys. 2123.

Survey of principles and phenomenology of modern physics, including atomic structure, nuclear phenomena and the interaction of radiations with matter.

Text: at the level of Weidner and Sells, *Elementary Modern Physics*.

Phys. 3002. The Solid State

3-0-3. Prerequisite: Phys. 2123.

Introductory solid state physics for engineers and applied scientists, using seven exemplary materials to illustrate the important properties of solids based on their atomic structure.

Text: at the level of Moore, *Seven Solid States*.

Phys. 3021. Nuclear Astrophysics and Stellar Evolution

3-0-3. Prerequisite: Phys. 2123.

Nucleosynthesis and energy generation in stars, stellar models and stellar evolution. Formation of elements, supernovae, quasars, neutron stars, "black-holes" and radio sources. All majors.

Text: at the level of Fowler, *Nuclear Astrophysics*.

Phys. 3121-2-3. Classical Mechanics, Electricity and Magnetism

5-0-5 each. Prerequisite: Phys. 2123, Math. 2309 concurrent with 3121, courses to be taken in sequence.

Dynamics of particles including oscillations and planetary motion, rotation of rigid bodies, collisions, Lagrange's equations. Electric and magnetic fields, potentials, resistance, inductance and

capacitance, polarization, magnetic materials, development of Maxwell's equations and their application to the transmission of electromagnetic waves.

Text: at the level of Symon, *Mechanics* and Lorrain and Corson, *Introduction to Electromagnetic Fields and Waves*.

Phys. 3132. Intermediate Mechanics

3-0-3. Prerequisite: Phys. 2123.

Mechanics of particles and rigid bodies, gravitation, moments of inertia, the conservation laws, hydrodynamics, elasticity and stress and strain.

Text: at the level of Constant, *Theoretical Physics (Mechanics)*.

Phys. 3136. Intermediate Electricity and Magnetism

3-0-3. Prerequisite: Phys. 2123.

Maxwell's equations and applications. Electrostatics, dielectrics, magnetostatics, magnetic substances, Ampere's and Faraday's laws, electrical circuits.

Text: at the level of Duckworth, *Electricity and Magnetism*.

Phys. 3141. Thermal Physics

5-0-5. Prerequisite: Phys. 2123 and Math. 2308.

Thermodynamics and introduction to statistical mechanics. Heat, temperature, entropy. Reversible, irreversible and quasi-static processes. Thermodynamic potentials. Magnetic thermodynamics. Maxwell-Boltzmann distribution. Microcanonical and canonical ensembles.

Text: at the level of Callen, *Thermodynamics*.

Phys. 3143. Quantum Mechanics I

5-0-5. Prerequisite: Phys. 3121 or 3132 and Math. 2309.

Historical approach to wave me-

chanics. Operator, eigenfunction-eigenvalue problem solutions to Schroedinger's equation, free particle, particle in a box, the square well, harmonic oscillator, rigid rotator and hydrogen atom.

Text: at the level of Eisberg, *Fundamentals of Modern Physics*.

Phys. 3145. Introductory Statistical Physics

3-0-3. Prerequisite: Phys. 2123.

Introduction to the concepts and principles of statistical physics necessary for a microscopic understanding of thermodynamics and related macroscopic phenomena.

Text: at the level of Kittel, *Thermal Physics*.

Phys. 3211. Electronics

5-6-7. Prerequisite: Phys. 2123.

A. C. circuit theory and basic principles of amplifiers and other electronic circuits.

Text: at the level of Mitchell, *Essentials of Electronics*.

Phys. 3223. Geometrical Optics

3-0-3. Prerequisite: Phys. 2123 and Math. 2308.

Development of optical analysis of lenses and reflectors using matrix theory. Coverage includes image formation, stops, aberrations, photometry and analysis of typical optical systems.

Text: at the level of Blaker, *Geometric Optics*.

Phys. 3224. Optical Instruments Laboratory

1-3-2. Corequisite: Phys. 3223.

Use of optical instruments for purposes of observation and measurement. Instrumentation includes spectrometers, interferometers, polariscopes, microscopes and telescopes.

Phys. 3225. Fourier Optics

3-0-3. Prerequisite: Phys. 2123 and Math. 2308.

A discussion of physical optics using Fresnel-Kirchhoff integral equation. Abbe theory of image formation. Coherence, polarization. Maxwell equations as the basis for physical optics.

Text: at the level of Klein, *Optics*.

Phys. 3226. Advanced Optical Physics Laboratory

1-3-2. Corequisite: Phys. 3225.

Optional laboratory taken with Physics 3225. A small number of experiments designed to exemplify the material presented in lecture course.

Phys. 3229. Vacuum Ultraviolet Optics

1-3-2. Prerequisite: Phys. 2123.

Laboratory and lecture concerned with sources, dispersion techniques and detectors in the approximate wavelength region of 100 to 2000 Angstrom units.

Text: at the level of Sampson, *Techniques of Vacuum Ultraviolet Spectroscopy*.

Phys. 3241. Elementary Biophysics I

3-0-3. Prerequisite: Phys. 2123.

Applications of the principles and techniques of the physical sciences to areas of the life sciences.

Text: at the level of Ackerman, *Biophysical Science*.

Phys. 3243. Elementary Biophysics II

3-0-3. Prerequisite: Phys. 3241.

A continuation of topics from Physics 3241. Physics of viruses, the central nervous system and biophysical instrumentation.

Text: at the level of Ackerman, *Biophysical Science*.

Phys. 3244. Introductory Biophysics Laboratory

0-3-1. Corequisite: Phys. 3243.

This laboratory is taken at the student's option with Phys. 3243. Selected exercises exemplifying and reinforcing material presented in the lecture course.

Phys. 3251. Biophysics I

3-0-3. Prerequisite: Phys. 2123 and Bio. 2211.

An introduction to biophysical systems, first through the study of physical properties of biological macromolecules and then through selected studies of sensory systems in animals.

Text: at the level of Lehniger, *Bioenergetics*.

Phys. 3253. Biophysics II

3-3-4. Prerequisite: Phys. 3251.

Selected topics that stress the application of the measurement and analytical techniques of the physical sciences to studies of living systems.

Phys. 3261. Introduction to Elementary Particle Physics

3-0-3. Prerequisite: Phys. 2123.

Phenomenology of elementary particles. Historical introduction, list of particles, quantum numbers, conservation laws, selection rules, cross sections, decays, strong, electromagnetic, weak interactions: S-matrix, quantum field theory, models.

Text: at the level of Perkins, *Introduction to High Energy Physics*.

Phys. 3263-4. Selected Problems in Physics I, II

1-6-3 each. Prerequisite: Phys. 2123, courses may be taken in either order.

The numerical treatment of physics problems and experimental data pursued through the aid of

computer facilities. Phys. 3263 will emphasize the numerical solution of realistic physics problems illustrating diverse physical principles. Phys. 3264 will emphasize the treatment of data arising from physics experiments, including an introduction to on-line experiment control.

Phys. 3265. Introduction to Acoustics

3-0-3. Prerequisite: Phys. 2112 or 2122.

An introduction to the art and science of acoustics for students of varied backgrounds and interests. The emphasis is on the basic physical mechanisms which underlie all acoustical phenomena.

Text: at the level of Kinsler, *Fundamentals of Acoustics*.

Phys. 3751. Laser Physics

3-0-3. Prerequisite: Phys. 2123 and Math. 2308.

Principles of laser operation. Types of lasers. Survey lectures on the application of lasers to various fields. Course intended for both physics and non-physics majors. Phys. 3751 is the same as E.E. 4751.

Phys. 3900. Special Problems

Credit to be arranged. Prerequisite: consent of department.

Content of course will vary to allow offering of courses in special topics on demand or on experimental basis. Individual problems arranged with consent of faculty member.

Phys. 4141. Vibrations and Wave Motion

3-0-3. Prerequisite: Phys. 3123 or 3136.

Oscillations and wave motion of discrete and continuous mechanical systems. The course emphasizes those aspects of wave

motion common to many areas of physics.

Text: at the level of Morse, *Vibration and Sound*.

Phys. 4143. Quantum Mechanics II
5-0-5. Prerequisite: Phys. 3143 or equivalent.

Introduction to perturbation theory, identical particles, spin and semi-classical radiation theory. Applications to atomic physics.

Text: at the level of Park, *Introduction to Quantum Theory*.

Phys. 4145. Special Relativity
3-0-3. Prerequisite: Phys. 3123 or 3136.

Critique of Newtonian mechanics and Maxwell's equations. Postulates and development of Einstein's theory. Four-vector notation and relativistic mechanics.

Text: at the level of Sard, *Relativistic Mechanics*.

Phys. 4211. Electronic Instruments for Scientific Research

2-3-3. Prerequisite: Phys. 3211 or equivalent.

An intermediate course in electronic instruments and instrumentation as employed in research and general laboratory measurements.

Text: at the level of Littauer, *Pulse Electronics*.

Phys. 4212. Electronics Laboratory

0-3-1. Prerequisite: Phys. 3211 or equivalent.

Problems and techniques associated with the construction, calibration and maintenance of electronic instruments. Experience gained through actual construction, calibration and troubleshooting exercises.

Phys. 4213. Physical Measurements

3-0-3. Prerequisite: Phys. 3211 or equivalent.

Theory and techniques of measurement of fundamental electric and magnetic quantities under both static and dynamic conditions.

Phys. 4214. Physical Measurements Laboratory

0-3-1. Corequisite: Phys. 4213.

Taken at student's option with Phys. 4213. A set of laboratory exercises exemplifying and reinforcing material presented in the lecture course.

Phys. 4215. Interfacing Laboratory

1-6-3. Prerequisite: Phys. 3211 or equivalent.

Introduction to the interfacing of computers with scientific apparatus. A PDP-11 computer and a variety of interfacing logic is available for the laboratory.

Phys. 4216. Interfacing Laboratory II

1-6-3. Prerequisite: Phys. 4215 or consent of department.

A continuation of Phys. 4215. Emphasis on individual student design and construction of interfaces for on-line control of experiments.

Phys. 4261. Atomic Physics

5-0-5. Prerequisite: Phys. 3143 or equivalent.

The structure and spectra of ordinary atoms, mesic atoms and positronium. Atomic beams techniques. Double resonance and level-crossing spectroscopy. Optical pumping. Properties of leptons.

Text: at the level of Woodgate, *Elementary Atomic Structure*.

Phys. 4262. Molecular and Solid State Physics

5-0-5. Prerequisite: Phys. 3143; Phys. 3141 or Chem. 1113.

Application of quantum mechanics to molecules and solids. Molecular bonding and spectra of diatomic molecules. Binding forces and bond theory in solids. Applications to solid state devices.

Text: at the level of Kittel, *Introduction to Solid State Physics*.

Phys. 4263. Nuclear Physics

5-0-5. Prerequisite: Phys. 3143.

Basic properties of nuclei, interactions of radiation with matter, accelerators, radioactivity, nuclear reactions, nuclear models, elementary particles. Physics 6011 is an alternate in the health physics program.

Text: at the level of Evans, *The Atomic Nucleus*.

Phys. 4264. Plasma Physics

5-0-5. Prerequisite: Phys. 3123 or 3136.

Basic treatment of the plasma state via the Boltzmann equation, including collisions. Debye shielding length, diffusion, conductivity, oscillations and propagation of EM waves.

Text: at the level of Holt and Haskell, *Foundations of Plasma Dynamics*.

Phys. 4265. Transport Phenomena in Solids

3-6-5. Prerequisite: Phys. 2123; Phys. 3141 or Chem. 1113 or equivalent.

This course emphasizes an experimental approach to transport phenomena. Topics include electrical and thermal conductivity and related phenomena in metals, semiconductors and insulators.

Phys. 4266. Introductory Diffraction Studies

2-6-4. Prerequisite: senior standing or consent of department.

Introductory theory and practice of the most widely applicable x-ray and neutron diffraction techniques. Topics emphasized include identification, lattice parameters, textures, line breadth and crystal orientation.

Text: at the level of Azaroff, *Elements of X-Ray Crystallography*.

Phys. 4271. Stellar and Planetary Atmospheres

5-0-5. Prerequisite: Phys. 2123.

Essentials of physics necessary for interpreting stellar and planetary atmospheres and other astrophysical plasmas. Solar radiation, chemical change, atmospheric temperatures and evolution of atmospheres.

Text: at the level of Aller, *Astrophysics*.

Phys. 4321-2-3. Advanced Laboratory I, II, III

1-6-3 each. Corequisite: Physics 3143.

May be scheduled in any order. Experiments of classical and contemporary importance selected from various fields of physics. Experiments frequently deal with topics that have not been treated in other courses. Students will be expected to acquire an understanding of significance of experiments through independent study.

Phys. 4900. Special Problems

Credit to be arranged. Prerequisite: consent of department.

Courses in special topics may be offered under this number. Individual student problems may be arranged with the consent of a faculty member.

Phys. 6005. Computer Facilities for Graduate Research in Physics
1-6-3.

Introduction to the computational aspects of physics research and the characteristics of the computing systems available.

Phys. 6011. Principles of Nuclear Physics
4-0-4.

Radioactive decay and decay processes, interaction of radiation, statistical considerations in interactions, nuclear structure, stability and models, nuclear reactions and cross sections, properties of neutrons.

Text: at the level of Friedlander, Kennedy and Miller, *Nuclear and Radio Chemistry*.

Phys. 6012. Radiation Attenuation
3-3-4.

Interaction of radiation with matter in bulk, adsorption scattering and attenuation of nuclear radiations, radiation transport theory, geometrical considerations and transport solution methods.

Phys. 6121. Theoretical Mechanics
5-0-5.

Dynamics of particles and rigid bodies, including developments and applications of LaGrange's, Hamilton's and Euler's equations. Potential theory. Gyroscopic motion. Poisson brackets, Hamilton-Jacobi theory.

Text: at the level of Goldstein, *Classical Mechanics*.

Phys. 6122. Electrodynamics
5-0-5.

Discussion of Maxwell's equations, scalar and vector potentials, conservation laws, multipole moments and multipole radiation, dispersion.

Text: at the level of Panofsky and Phillips, *Classical Electricity and Magnetism*.

Phys. 6123. Statistical Mechanics
5-0-5. Corequisite: Phys. 6121.

Physical applications of probability theory. Classical and quantum statistical mechanics with numerous applications: ideal gas, imperfect gas, liquids and solids.

Text: at the level of Reif, *Fundamentals of Statistical and Thermal Physics*.

Phys. 6131. Mechanics of Continuous Media
3-0-3.

Dynamics of deformable bodies. Strain and stress, waves. Hydrodynamics of fluids: Bernoulli's theorem, Stokes' law, waves, vortex motion, viscous fluids.

Text: at the level of Page, *Introduction to Theoretical Physics*.

Phys. 6132. Advanced Electricity and Magnetism
5-0-5.

A study of Maxwell's equations with applications to problems in electrical power systems, communications, signal processing, radiation and electrical measurements.

Phys. 6141. Quantum Mechanics I
5-0-5. Prerequisite: Phys. 4143 or equivalent.

Nonrelativistic quantum mechanics. Representation of dynamical variables as operators or matrices, theory of angular momentum, perturbation theory, selected topics from radiation and scattering theory.

Text: at the level of Merzbacher, *Quantum Mechanics*.

Phys. 6142. Quantum Mechanics II
5-0-5. Prerequisite: Phys. 6141.

Relativistic quantum mechanics, Dirac theory, the Lorentz group, antiparticles, relativistic Hamiltonians, propagators, Feynman graphs.

Text: at the level of Borken and Drell, *Relativistic Quantum Mechanics*.

Phys. 6143. Quantum Mechanics III
5-0-5. Prerequisite: Phys. 6141.

A problem-solving course that applies principles of quantum mechanics to areas of physics such as atomic, molecular, solid-state and nuclear physics.

Phys. 6231. Introductory Solid State Physics
3-0-3.

Brillouin zone treatment of metals, semiconductors, insulators. Approximation methods for estimating properties of real solids. Comparisons between theory and experiment for selected solid state phenomena.

Text: at the level of Kittel, *Introduction to Solid State Physics*.

Phys. 6233. Physical Crystallography
3-0-3. Prerequisite: Phys. 4266 or equivalent.

Experimental and analytical aspects of x-ray, neutron and electron diffraction crystallography applied to problems such as physical property mechanisms, defects and other topics of current physical interest.

Phys. 6235. Physics of Surfaces
3-6-5.

Fundamentals of physical methods for studying the structure, composition, vibrational and electronic properties of solid surfaces

including the verification of principles in laboratory experiments.

Phys. 6251. Diatomic Molecules
3-0-3. Prerequisite: Phys. 4143 or equivalent.

Electronic structure, calculation of potential energy curves, absorption parameters, emission parameters, rotational line strengths, vibrational band strengths, calculation of Franck-Condon factors.

Phys. 6261. Plasma Physics and Thermonuclear Physics
3-0-3.

Particle trajectories in electric and magnetic fields. Space charge and current sheaths. Plasma formation and confinement. Oscillations, waves and instabilities. Radiation from plasmas.

Phys. 6263. An Introduction to Collision Theory
3-0-3. Prerequisite: Phys. 4143 or equivalent.

Quantum theory of non-relativistic elastic and inelastic scattering, rearrangement collisions, central, non-local, absorptive interactions, phase shift analysis, variational methods, semiclassical and impulse approximations, transition probabilities.

Phys. 6264. The Theory of Atomic Collisions
3-0-3. Prerequisite: Phys. 6263.

Collisional excitation and ionization involving electrons, atoms and molecules. Charge-transfer, recombination, ion-molecule reactions. Atomic processes in planetary atmospheres in astrophysics and in laboratory plasmas.

Phys. 6267. Atomic Collisions
3-0-3.

A discussion of the techniques by which atomic collisions phenomena are studied, includes scattering of ions and electrons in gases and scattering from solid surfaces.

Phys. 6300. Graduate Laboratory
1-6-3.

Students choose a program of several experiments from those available in varied fields such as nuclear physics, solid state physics, x-ray diffraction, optics and physics instrumentation.

Phys. 6753. Surface Science and Technology Laboratory

3-18-9. Prerequisite: consent of department.

A highly specialized laboratory course using modern analytical and research instrumentation to characterize and study the surface properties of materials. Also listed as Ch.E. and Chem. 6753.

Phys. 7000. Master's Thesis

Phys. 7123. Statistical Mechanics II

5-0-5. Prerequisite: Phys. 6123.

An advanced course in statistical mechanics, including problems of biological significance.

Phys. 7125. Introduction to Relativity

5-0-5. Prerequisite: Phys. 6121, 6122.

Reference frames and transformations, tensor calculus, review of special relativity, electrodynamics, the principle of equivalence, general relativity and gravitation, scalar-tensor theories.

Phys. 7141. Quantum Mechanics of Many-particle Systems

5-0-5. Prerequisite: Phys. 6141.

Interacting systems of particles described quantum mechanically using the method of second quantization. Application to Fermi and Bose systems.

Phys. 7143. Group Theory and Quantum Mechanics

5-0-5. Prerequisite: Phys. 6141 or equivalent.

Basic principles of group theory and the representation of groups by matrices. Applications will include atomic and molecular structure.

Phys. 7147. Quantum Field Theory

5-0-5. Prerequisite: Phys. 6141, 6122.

Quantum theory of free fields: scalar, vector and spinor fields. Conservation laws. S-matrix. Quantum electrodynamics.

Phys. 7261. Optical Properties of Solids

3-0-3. Prerequisite: Phys 6231.

Classical treatment of dielectrics and metals. Fresnel equations and Kramers-Kronig relation. Quantum mechanical treatment of selected topics. Emphasis on experimental determination of optical constants.

Phys. 7263. Nuclear Physics

5-0-5. Prerequisite: Phys. 6141.

Use of nuclear models in computation of observable nuclear phenomena, including static and dynamic electromagnetic properties of nuclei.

Phys. 7265. Neutron Investigation of Condensed Matter

3-0-3. Prerequisite: Phys. 6141.

Time-dependent correlation functions and dynamical structure factors. Coherent and incoherent,

elastic and inelastic scattering cross sections. Applications to neutron scattering by photons, magnetic interactions, fluids.

Phys. 7999. Preparation for the Comprehensive Examination

Phys. 8001-2-3. Graduate Student Seminar

1-0-1.

Acquaints first-year graduate students with research in School of Physics. Seminars mainly given by graduate students finishing Doctoral thesis research and by post-doctoral fellows.

Phys. 8011-2-3. Phys. Seminar

1-0-0.

Phys. 8501-2-3. Special Problems
Credit to be arranged.

Phys. 8511-2-3. Special Problems
Credit to be arranged.

Phys. 8999. Preparation for Doctoral Dissertation

Noncredit. Prerequisite: consent of department.

Phys. 9000. Doctoral Thesis

Psychology

Psy. 3300. Psychology and Contemporary Issues in Society
3-0-3.

Contributions of psychology to an appreciation of selected contemporary issues. Topics may vary from quarter to quarter.

Psy. 3303. General Psychology A
3-0-3.

An intensive coverage of the methods and findings of contemporary psychology. Includes such topics as psychological development, learning, conditioning and biological bases of behavior.

Psy. 3304. General Psychology B
3-0-3. Prerequisite: Psy. 3303.

A continuation of Psychology 3303. Such topics as individual differences, perception and personality will be discussed.

Psy. 4400. Developmental Psychology

3-0-3. Prerequisite: Psy. 3303.

A comprehensive study of human behavior and development from infancy through adolescence. Emphasis is placed on empirical and cross-species contributions.

Psy. 4401. Industrial Psychology
3-0-3.

A survey of methods and findings in the scientific study of humans at work. Considered are such topics as selection, training, motivation, accidents and environmental effects.

Psy. 4402. Psychology of Adjustment

3-0-3. Prerequisite: Psy. 3303.

Consideration of characteristics and etiology of typical and atypical human behavior. A principle objective is an increased understanding of self and others.

Psy. 4403. Introduction to Psychological Testing

3-0-3. Prerequisite: Psy. 3304 or 4401.

Consideration of the theoretical and practical issues in psychological measurement, with particular reference to psychological testing.

Psy. 4404. Psychology of Advertising

3-0-3. Prerequisites: Psy. 3303, 4401.

An analysis of psychological principles and techniques which serve as a foundation for effective

advertising. The scientific study of consumer behavior is emphasized.

Psy. 4405. Seminar in Organizational Psychology

3-0-3. Prerequisite: Psy. 4401 or 4410.

Study of psychological factors in organizational functioning, including theoretical and research issues.

Psy. 4406. Psychological Statistics

2-3-3. Prerequisite: consent of department.

Application of statistical techniques to the design and analysis of psychological studies.

Psy. 4407. Experimental Psychology I

2-3-3. Prerequisite: Psy. 3303.

An introduction to psychological measurement and laboratory techniques used in the experimental study of topics such as sensory processes, perception, psychomotor performance and learning.

Psy. 4409. Introduction to Engineering Psychology

3-0-3.

Engineering psychology is presented as an integral component in the design and evaluation of man/machine systems. Applied problems and general methodological questions are examined.

Psy. 4410. Social Psychology

3-0-3. Prerequisite: Psy. 3303.

Consideration of the behavior of the individual in relation to other individuals and groups.

Psy. 4411. Experimental Psychology II

3-3-4. Prerequisite: Psy. 3304, 4407 and consent of department.

Consideration of principles and

research methods in the areas of learning and motivation with special emphasis on classical and operant conditioning of non-human animals.

Psy. 4412. Psychology of Learning

3-3-4. Prerequisite: Psy. 3304, 4406, 4407 and consent of department.

An empirical and theoretical analysis of human learning, memory and cognitive processes.

Psy. 4413. Applied Experimental Psychology

3-3-4. Prerequisite: Psy. 4406, 4412 and consent of department.

Consideration of the applications of the methods and data of experimental psychology.

Psy. 4421. Physiological Psychology

3-0-3. Prerequisite: Psy. 3304, Biol. 2211.

Neurophysiological, endocrinological and biochemical bases of sensory and motor functioning, learning, memory, motivation and behavior disorders.

Psy. 4422. Comparative Psychology

2-2-3. Prerequisite: Biol. 2211, Psy. 3304 and consent of department.

Consideration of principles and research methods of animal psychology and ethology. Literature reviews and reports, field trips and laboratory studies.

Psy. 4423. Introduction to Psycholinguistics

3-0-3. Prerequisite: consent of department.

A critical examination of current psychological research and theory in language development and behavior.

Psy. 4424. Introduction to Personality

3-0-3. Prerequisite: Psy. 3304 or Psy. 4410 and consent of department.

Introduction to and survey of major theories of personality.

Psy. 4750. Social Psychology – Sociology Measurement Seminar

3-0-3. Prerequisite: Psy. 4410 or equivalent and consent of department.

Problems, implications and methodologies relating to the measurement of individual and group behavior in social situations. Students will receive supervised project experience. Also taught as Soc. 4750.

Psy. 4751. Psychology and Environmental Design I

3-3-4. Prerequisite: consent of department.

Introduction to psychological concepts relevant to environmental design. Survey of selected methods for assessing man-made environment. Taught jointly by psychology and architecture faculty. Also taught as Arch. 4751.

Psy. 4752. Psychology and Environmental Design II

3-3-4. Prerequisite: Psy. 4751 and consent of department.

Continuation of 4751 with greater emphasis on independent research and development of design solutions to selected problems. Taught jointly by psychology and architecture faculty. Also taught as Arch. 4752.

Psy. 4754. Models of Human Information Processing

3-0-3. Prerequisite: Psy. 3303, 3304.

General and unified approaches to psychological and computer

modeling of human information processes. Emphasis on neural, sensory, memory, semantic and conceptual processing. Also listed as I.C.S. 4754.

Psy. 4800. Special Topics

1-3-2. Prerequisite: Psy. 3304, 4407 and consent of department.

Guided independent study in an area of psychology not represented in departmental course offerings.

Psy. 4814. Special Topics

0-3-1. Prerequisite: Psy. 4406, 4411 and consent of department.

The student will, under the direction of a staff member, do semi-independent work in literature review and/or experimental design.

Psy. 4815. Special Topics

3-3-4. Prerequisite: consent of department.

Student will work, under the direction of the instructor, on projects adding to their development beyond the scope of existing courses.

Psy. 4900. Special Problems

Credit to be arranged. Prerequisite: consent of department.

Students engage in individual and group projects under the direction of a faculty member.

Psy. 4953. Special Problems in Psychological Aspects of Environmental Design

Credit to be arranged. Prerequisite: Psy. 4751, 4752 and consent of department.

Supervised individual study of a problem relating to the interaction of environmental design and behavior.

Psy. 6601. Advanced Industrial Psychology

3-0-3. Prerequisite: Psy. 4401.

A survey of theoretical and pragmatic issues in industrial psychology. Recent developments and experimental findings will be discussed.

Psy. 6602. Applied Experimental Psychology

3-0-3. Prerequisite: Psy. 3304.

Consideration of the application of the methods and data of experimental psychology to the problems of man and his environment, emphasizing the engineering psychology approach.

Psy. 6603. Social Psychology

3-0-3. Prerequisite: six hours of psychology and consent of department.

A study of principles of social learning, motivation and perception and of attitudes and beliefs as they relate to behavior of individuals in groups.

Psy. 6604. Human Information Processing

3-0-3. Prerequisite: consent of department.

A study of information processing theories and measurements techniques as applied to psychological problems, emphasizing human perceptual, communication and learning processes.

Psy. 6605. Proseminar in General Psychology

3-0-3. Prerequisite: graduate standing and consent of department.

A comprehensive, advanced consideration of general psychology including such topics as learning, motivation and cognitive processes.

Psy. 6606. Proseminar in General Psychology

3-0-3. Prerequisite: graduate standing and consent of department.

A comprehensive, advanced consideration of general psychology including such topics as psychological development, perception and physiological psychology.

Psy. 6607. Proseminar in General Psychology

3-0-3. Prerequisite: Psy. 6605, 6606 or equivalent and consent of department.

A continuation of Psy. 6605 and 6606 involving consideration of such topics as personality, individual differences and social psychology.

Psy. 6608. Human Motivation

3-0-3. Prerequisite: graduate standing, Psy. 6605 and consent of department.

Examines theoretical and pragmatic issues in the description and prediction of motivated behavior. Includes the measurement problems, implications and applications in a range of settings.

Psy. 6609. Social Psychology of Organizations

3-0-3. Prerequisite: Psy. 4410 or equivalent and consent of department.

Selected topics from social psychology which are of particular significance to an understanding of individual behavior in an organizational context. Supervised readings and discussion.

Psy. 6610. Psychoacoustics

3-0-3. Prerequisite: Psy. 3304 or equivalent and consent of department.

A comprehensive coverage of physiological and psychological acoustics, including analyses of

auditory and extra-auditory response mechanisms and evaluation of research and theories in hearing.

Psy. 6621-2. Foundations of Psychology

3-0-3 each. Prerequisite: graduate standing and consent of department.

A sequence involving historical and current points of view in psychology, emphasizing issues important for psychological theory.

Psy. 6623-4. Design of Psychological Experiments

2-3-3 each. Prerequisite: graduate standing, Math. 2206, Psy. 4406 or equivalent and consent of department.

A two-quarter sequence on the planning and implementation of research based on linear models, with reference to statistical considerations in data reduction and analysis.

Psy. 6625. Experimental Methods in Psychology

2-3-3. Prerequisite: graduate standing, Psy. 6605, 6606, 6623 or equivalent and consent of department.

Measuring the dependent variable in psychological experiments. Discussion is supplemented by practice in designing, conducting and reporting experiments.

Psy. 6626. Response Evaluation

3-0-3. Prerequisite: graduate standing, Psy. 4406 or equivalent and consent of department.

Intensive consideration of theoretical and pragmatic problems in the description and evaluation of human response in such areas as task analysis and performance measurement.

Psy. 6627. Human Learning

3-0-3. Prerequisite: graduate standing, Psy. 3303 or equivalent and consent of department.

A comprehensive consideration of principles, problems, methods and experimental data in the study of human learning, including discussion of applications of theory and experimental findings.

Psy. 6629. Psychomotor Skill Learning and Performance

3-0-3. Prerequisite: Psy. 4406, 6605, 6606 or equivalent.

Human capabilities and limitations for learning and performing psychomotor skills are studied. Emphasis is on performance measurement and assessment of skill proficiency, prediction and control.

Psy. 6630. Psychometric Theory

3-0-3. Prerequisite: Psy. 4403, 6624 or equivalent.

Preparation of students in statistical theory and techniques relevant to becoming professionally involved in construction, analysis and evaluation of psychological and personnel tests.

Psy. 6680. Multivariate Analysis

5-0-5. Prerequisite: Psy. 6624 or equivalent and consent of department.

Introduction to multivariate analysis in psychology with special emphasis on factor analysis.

Psy. 7000. Master's Thesis

Psy. 7010. Seminar in Industrial Psychology

3-0-3. Prerequisites: Psy. 6601, 6607 and consent of department.

Critical and comprehensive examination of current problems in a selected area of industrial psychology. The area to be covered may vary from year to year.

Psy. 7011. Seminar in Experimental Psychology

3-0-3. Prerequisite: Psy. 6607, 6625 and consent of department.

Critical examination of current problems in a selected area of general experimental psychology. Area to be discussed may vary each time the course is offered.

Psy. 7012. Seminar in Engineering Psychology

3-0-3. Prerequisite: Psy. 6602, 6607 and consent of department.

Critical examination of current problems in a selected area of engineering psychology. The area to be discussed may vary each time the course is offered.

Psy. 7020. Advanced Learning

4-0-4. Prerequisite: graduate standing, Psy. 6605 or equivalent and consent of department.

An advanced and systematic examination of selected topics dealing with the experimental analysis of learning. Theoretical approaches to learning, transfer and retention will be discussed.

Psy. 7021. Sensation and Perception

4-0-4. Prerequisite: Psy. 6606 or equivalent and consent of department.

An examination of human interpretation of physical stimulation. The student studies in some detail the nature of perceptual processes, including human sensory processes.

Psy. 7022. Vision

3-0-3. Prerequisite: Psy. 6606 or equivalent.

An advanced examination of the visual processes and the fundamental role they play in human behavior. Emphasis is placed upon objectively obtained data.

Psy. 7023. Operant Conditioning

4-0-4. Prerequisite: Psy. 6605 or equivalent.

Intensive treatment of methods, data and problem areas of operant conditioning. Among the topics covered are response differentiation, schedules of reinforcement and stimulus control.

Psy. 7050. Professional Problems

2-0-2. Prerequisite: graduate standing and consent of department.

Introduces the student to professional problems which he may face as a psychologist, including teaching, professional practice and research. Ethical issues will be examined.

Psy. 7750. Seminar on Psychology and Management

3-0-3. Prerequisite: Psy. 6601, 6609, I.M. 6150 or 6105 and consent of department.

Preparation and discussion of papers on management problems involving psychological complexities. Jointly taught by members of the psychology and industrial management faculties.

Psy. 8504. Special Problems in Industrial Psychology

Credit to be arranged. Prerequisite: Psy. 6601, 6602 or 6603.

Students will be expected to plan and execute a research problem involving investigation of some psychological aspect of management problems.

Psy. 8505. Special Problems in Experimental Psychology

Credit to be arranged. Prerequisite: consent of department.

Students conduct research under direction of a faculty member on problems in the general area of experimental psychology.

Psy. 8506. Special Problems in Engineering Psychology

Credit to be arranged. Prerequisite: Psy. 6602 or equivalent and consent of department.

Students conduct research under direction of a faculty member on problems in the area of engineering psychology.

Psy. 9000. Doctoral Thesis**Social Sciences****History****Hist. 1001. History of the United States to 1865**

3-0-3. Normally open to freshmen only.

A survey of the social, political and economic history of the United States through the Civil War with emphasis on selected topics. Gives exemption from U.S. and Georgia history examination.

Hist. 1002. History of the United States from 1865 to the Present

3-0-3. Normally open to freshmen only.

A survey of the social, political and economic history of the United States from the Civil War to the present with emphasis on selected topics. Gives exemption from U.S. and Georgia history examination.

Hist. 3001. Origins of Modern Times: Western Civilization, 1500-1789

3-0-3.

The course traces consolidation of the national monarchies and formation of the modern state system. In intellectual history, it follows the growth of secular culture.

Hist. 3003. Nineteenth Century Europe

3-0-3.

Modern European history and its impact on world civilization.

Hist. 3004. World Problems Since 1914

3-0-3.

A continuation of Hist. 3003.

Hist. 3010. History of the United States to 1865

3-0-3. Normally taken by juniors and seniors. Not open to students who have had History 1001.

A survey of the social, political and economic history of the United States through the Civil War period with emphasis on selected topics. Gives exemption from the U.S. and Georgia history examination.

Hist. 3011. History of the United States from 1865 to the Present

3-0-3. Normally taken by juniors and seniors. Not open to students who have had History 1002.

A survey of the social, political and economic history of the United States from the Civil War to the present with emphasis on selected topics. Gives exemption from U.S. and Georgia history examination.

Hist. 3012. History of Georgia

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

The problems which have confronted Georgia are examined in their historical setting. Relationship to the national scene gives perspective to state's place in the nation.

Hist. 3013. United States Colonial History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Settlement and growth of the English colonies in North America with emphasis on the foundations of American political and economic institutions.

Hist. 3017. History of the Old South to 1865

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

A study of social, political and economic developments in the South from the colonial period through the Civil War.

Hist. 3018. History of the New South Since 1865

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Continues Hist. 3017. An examination of social, political and economic developments from the Reconstruction period to the present.

Hist. 3020. American Diplomatic History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Historical analysis of diplomacy since the Revolutionary War. Emphasis upon political, economic and social factors and upon role of the South in world affairs.

Hist. 3022. Afro-American History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Historical analysis of the American Negro to the present. Special attention given to the Negro's contribution to American letters, music and other performing arts.

Hist. 3024. The American Civil War

3-0-3. Prerequisite: any one of

Hist. 1001, 1002, 3010, 3011 or history examination.

A survey of the major political, economic and military events occurring in both the Union and the Confederacy during the American Civil War.

Hist. 3025. American Economic History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Special attention given to the rise of technology, our industrial system, the westward movement, development of our banking system and government regulation of industry.

Hist. 3028. United States Social and Intellectual History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Studies in the social and intellectual traditions of the United States with emphasis on the more recent period. Assigned readings.

Hist. 3030. Technology and Economic Change

3-0-3.

Growth of technology in the modern world in its relationship to economic and social change.

Hist. 3040. Recent Latin American History

3-0-3.

Historical evolution of Latin America in recent times with particular attention to social change.

Hist. 4025. The United States Since 1917

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Social, political, economic and diplomatic history of the United

States in the middle of the twentieth century is examined as to causes, results and movements.

Hist. 4050. Twentieth Century Black History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

The inequities and achievements of the period are dealt with through an analysis of selected topics.

Hist. 4075. The City in American History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Selected topics concerning the social, economic and political history of American cities with emphasis on the role of technology in urban development.

Hist. 4925-6-7-8-9. Special Problems in History

Credit to be arranged.

Philosophy and History of Science

P.H.S. 1126. Introduction to Philosophical Analysis

3-0-3.

An introduction to the nature of philosophy through critical study of selected works. The relation of philosophy to science, religion and society will be emphasized.

P.H.S. 1127. Science, Technology and Human Values

3-0-3.

An introductory study of the impact of science and technology on the religious, ethical and social values in the Western tradition.

P.H.S. 1128. Introduction to the History of Science and Technology

3-0-3.

An interpretive study of development of science and technology to the present. Includes examination of historical details and the consequences of scientific, industrial and technological revolutions.

P.H.S. 3100. Introduction to Philosophical Analysis

3-0-3.

Through critical study of selected works the relation of philosophy to science, religion and society will be emphasized.

P.H.S. 3102. History of Ancient Philosophy

3-0-3.

A study of the development of philosophy from the early pre-Socratics' scientific writings to Christian thought. The works of Plato and Aristotle stressed.

P.H.S. 3103. History of Modern Philosophy

3-0-3.

The development of Western thought from Bacon to Kant, with emphasis on the philosophic dimensions of the rise of modern science.

P.H.S. 3104. Contemporary Philosophy

3-0-3.

A study of the diverse movements in philosophy from Hegel to Russell with emphasis on the philosophic response to the development of modern scientific inquiry.

P.H.S. 3105. Types of Ethical Theory

3-0-3.

Critical examination of ethical theories, consideration of

theoretical problems of ethics, nature and presuppositions of ethical judgments, justification of ethical standards.

P.H.S. 3107. Contemporary Religious Thought

3-0-3.

Introduction to the development of the most important concepts in modern religious systems. Emphasis will be placed on the contributions of philosophical analysis and theological debate.

P.H.S. 3113. Symbolic Logic

3-0-3.

A first course in symbolic logic including the logic of statements and the logic of predicates.

P.H.S. 3115. Survey of Science in the 16th and 17th Centuries

3-0-3.

A study of the scientific discovery and scientific methods from the Age of Galileo to the Enlightenment.

P.H.S. 3116. Survey of Science in the 18th and 19th Centuries

3-0-3.

The growth and expansion of modern science from Lavoisier to the close of the 19th century.

P.H.S. 3117-8-9. History of Engineering

3-0-3 each.

A study of the development of engineering from ancient times to about 1930. Aspects of engineering with greatest importance for future development will be stressed.

P.H.S. 3120-1-2. Philosophy of Science

3-0-3 each.

A study of the main problems of philosophy of science including theories, explanation, prediction,

causality, development of scientific knowledge, social and ethical aspects of science.

P.H.S. 4106. Philosophy of the Behavioral and Social Sciences

3-0-3. Senior standing or consent of the department.

Examination of philosophical views of social science, structural aspects of social science, relationship between natural and social science and other selected philosophical problems.

P.H.S. 4107. Philosophy of Technology

3-0-3. Senior standing or consent of the department.

Examination of selected problems such as interface between the individual and technology, artificial intelligence, epistemology and metaphysics of technology.

P.H.S. 4108. History of Technology in the United States

3-0-3.

An introduction to the development of technology in the United States as interwoven with its economic and social background and influence.

P.H.S. 4110. Theories of Knowledge

3-0-3.

Critical examination of perception, verification, *a priori* and *a posteriori* knowledge, meaning and criteria of truth, presuppositions and cognitive significance of scientific and philosophical propositions.

P.H.S. 4115. Philosophy of Science

3-0-3.

Examination of selected problems such as causality, induc-

tions, scientific explanation, development of scientific knowledge, social and philosophical import of scientific theories.

P.H.S. 4116. History of Electrical Science and Technology

3-0-3. Senior level or consent of department.

An interpretive study of the origins and evolution of electrical science and technology since the 17th century.

P.H.S. 4120. Semantics

3-0-3. Normally taken by seniors.

The relations of formal logic and natural languages, sense and reference, semantical paradoxes, semantic criteria of truth.

P.H.S. 4944-5-6-7-8. Selected Problems in the History of Science

Credit to be arranged.

P.H.S. 4949. Special Problems

Credit to be arranged.

P.H.S. 8549. Special Topics

3-0-3.

Topics to be selected.

Political Science

Pol. 1251. Government of the United States

3-0-3.

Study of structure and function of governments of United States and Georgia. Gives exemption from United States and Georgia Constitution examination.

Pol. 1253. Comparative Political Systems

3-0-3.

Examination of current empirical political frameworks and conceptual vocabularies for purpose of developing common approach in

analysis of individual political systems.

Pol. 2270. Introduction to Analysis of Political Behavior

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Introduction to political analysis — behavior and post-behavioral perspective. Explores basic concepts employed in selected theoretical approaches.

Pol. 2271. American Political Thought

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Examination and analysis of fundamental political thoughts which have shaped the American political system.

Pol. 3200. American Constitutional Problems

3-0-3.

Study of structure and function of United States and Georgia government, taught largely through medium of constitutional law. Gives exemption from United States and Georgia Constitution examination.

Pol. 3203. National Defense Policy

3-0-3. Prerequisite: Pol. 1251 or consent of department.

Analysis of security policies of United States in domestic and international situations.

Pol. 3204. United States Military Policies

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Critical examination of American military policies from the Revolution to present.

Pol. 3205. American Foreign Policy

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Study of formulation of foreign policy and structure and function of the State Department.

Pol. 3207. State and Local Government

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Analysis of structure and function of state, county and municipal governments.

Pol. 3210. National Legislative Processes

3-0-3. Prerequisite: Pol. 2270 or consent of the department.

Empirical and systematic analysis of national legislative branch with attention to relationships among executive branch, interest groups and Congress.

Pol. 3211. The American Presidency

3-0-3. Prerequisite: Pol. 1251, 2270 or consent of the department.

Source, nature and use of presidential power, the roles of the president. Recent historical examples emphasized.

Pol. 3216. American Political Parties

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Study of political party developments and their role in the electoral process.

Pol. 3217. State and Local Government

3-0-3. Prerequisite: Pol. 1251 or consent of department.

Analysis of structure and function of state, county and municipal government.

Pol. 3220. Urban Government and Political Problems

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

An examination of political in-

stitutions and processes in the urban setting, including metropolitan government and intergovernmental relations.

Pol. 3221. Urban Political Problems

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

A consideration of urban political behavior, including brokerage politics, politics in suburbia and community power structures.

Pol. 3222. Urban Public Policy

3-0-3. Prerequisite: Pol. 3220, 3221 or consent of the department.

An empirical and systematic analysis of selected urban public policy areas, possibly including such policy areas as education, housing and crime control.

Pol. 3250. Public Administration and Public Policy

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Study of decision making and organization theory, bureaucratic policymaking, intergovernmental relations, taxing and spending policy focus.

Pol. 3265. Latin American Governments and Politics

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

A survey of governmental and political processes in Latin American countries.

Pol. 3266. The Developing Nations

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Study of selected underdeveloped nations including economic and political development.

Pol. 3270. Western European Governments and Politics

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Comparative analysis of governmental and political processes in the nations of Western Europe.

Pol. 3275. Foundations of National Power and International Relations

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Study of U. S. power position in world affairs.

Pol. 3276. International Organization

3-0-3. Prerequisite: Pol. 3275 or consent of the department.

Study of evolution, impact and future of international organizations.

Pol. 3280. Communist Political Systems

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

An analysis of governmental and political processes in the communist governments.

Pol. 3281. Soviet Foreign Policy

3-0-3. Prerequisite: Pol. 3280 or consent of the department.

Study of formulation and conduct of Soviet foreign policy. Consideration of ideological, geopolitical influences, development of relations with western world.

Pol. 4200. Political Theory I

3-0-3. Prerequisite: Pol. 1251 or consent of department.

A study of ancient, medieval, renaissance and reformation political philosophy.

Pol. 4201. Political Theory II

3-0-3. Prerequisite: either Pol. 1251, 4200 or consent of the department.

The development of political

philosophy from the 17th century age of reason through the 19th century age of ideology.

Pol. 4202. Political Theory III

3-0-3. Prerequisite: either one of Pol. 1251, 4200, 4201 or consent of the department.

An analysis of contemporary political philosophy, emphasizing radical ideologies.

Pol. 4210. Science, Technology and Public Policy

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Examination of relationship between science and government including the effect of each area on the other in decision-making processes.

Pol. 4211. Science, Technology and World Politics

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Analysis of impact of science-technology on international system: role of science and technology in foreign policy process.

Pol. 4250. Policy Analysis and Evaluation

3-0-3. Prerequisite: Pol. 3250 or consent of department.

Study of the policy adviser in and out of government, social indicators and social accounting, evaluation of public policy, evaluation research techniques.

Pol. 4950, 4953-4-5-6. Special Problems in Political Science

Credit to be arranged.

Pol. 4951. Georgia Internship Program

Credit to be arranged (15 hours maximum).

Work-study program assigning student to project in state or local

government. Student prepares research paper under jurisdiction of faculty member.

Pol. 4952. Legislative Intern Program

Credit to be arranged.

Service learning program combining an academic study of the legislative process with internship at Georgia Legislature in winter quarter. Interns selected competitively each year.

Pol. 6951. Governor's Intern Program

Credit to be arranged.

Directed reading and research for students to work as interns in departments of state government.

Pol. 6952. Legislative Intern Program

Credit to be arranged.

Service learning program combining an academic study of the legislative process with internship at Georgia Legislature in winter quarter. Interns selected competitively each year.

Pol. 6255. Governmental Aspects of Planning

3-0-3.

Analysis and study of problems and solutions in the field of city planning.

Pol. 8574. Special Problems in Political Science

Credit to be arranged.

Topics to be selected.

Sociology

Soc. 1376. Introduction to the Principles of Sociology

3-0-3.

A study of basic social relations, including social structure and functions, analysis of social

processes, the foundations of personality and analysis of social organization.

Soc. 1377. Social Institutions

3-0-3. Prerequisite: Soc. 1376.

An analysis of the structure and functions of social institutions, including familial, educational, religious, economic and political. A study of institutional change and social disorganization.

Soc. 3306. Urbanization

3-0-3. Prerequisite: Soc. 1376.

Growth of metropolitan communities, differentiation of functions, urban complexity, ecological areas, the city as a way of life, measures and trends in the process of urbanization.

Soc. 3308. Statistics for Planning

3-0-3.

Statistical principles for analysis of economic, social and population data, sampling, measures of central tendencies, normal curve, testing of findings, correlation and arriving at conclusions.

Soc. 3310. Demographic Analysis

3-0-3. Prerequisite: Soc. 1376, 3308.

Factors affecting population problems, population growth, fertility, mortality, migration, distribution and composition.

Soc. 3330. Ethnic Minorities in American Society

3-0-3.

Analysis of social, economic and technological roles and contributions of various racial and cultural minorities in forming the American culture of today.

Soc. 3334. Social Stratification and Mobility

3-0-3. Prerequisite: Soc. 1376 or consent of the department.

Process of stratification, including the criteria for and characteristics of stratification. Implications of stratification for the functioning of society.

Soc. 3335. Social Problems of Industry

3-0-3. Prerequisite: Soc. 1376 or consent of the department.

A study of the nature of human relations in large-scale organizations, significance of authority, roles, communication, status and group norms in the work situation.

Soc. 3338. Individual and Society
3-0-3. Prerequisite: Soc. 1376 or consent of the department.

A study of the nature of interpersonal relations in small groups and in large social settings, a consideration of the problem of alienations and anomie.

Soc. 3339. Urban Sociology

3-0-3. Prerequisite: Soc. 1376.

Introduces student to basic concepts of sociology as applied to urban phenomena, nature of urbanism and consequences for social relations and human personality.

Soc. 3340. Urban Ecology and Demography

3-0-3. Prerequisite: Soc. 1376.

Involves application of ecological perspective to the study of urban phenomena, human spatial distribution theories of city location and patterns of city growth.

Soc. 3875-6-7. Special Topics

Credit to be arranged.

Topics to be selected.

Soc. 4306. Technology and Society

3-0-3. Normally taken by seniors or graduate students.

Analysis of social conditions

which promote or retard technological activity. Particular emphasis on the social role of the scientific and engineering professions in that development.

Soc. 4308. Seminar in Contemporary Urban Sociology

3-0-3. Prerequisite: Soc. 1376 and consent of the department.

Extensive and critical review of literature in field in order to keep students abreast of latest thinking concerning urban phenomena and problems.

Soc. 4312. Seminar in Comparative Urban Development

3-0-3. Prerequisite: Soc. 1376 and consent of department.

Entails cross-national comparison of cities and urban regions, appropriate models for understanding cities and urban regions and strategies for handling problems.

Soc. 4750. Social Psychology-Sociology Measurement Seminar

3-0-3. Prerequisite: Psy. 4410 or equivalent and consent of the department.

Problems, implications and applications relating to the measurement of individual and group behavior in social situations. Students will receive supervised project experience.

Soc. 4999. Special Problems in Sociology

Credit to be arranged.

Topics to be selected.

Soc. 6375. Planning for People

3-0-3.

Problems of planning with selected sub-groups in urban societies: minorities, the aged, residents of the inner city, suburbanites. Impact of environment on individuals and families.

Textile Engineering

Text. 1100. Introduction to Textile Engineering

3-0-3.

An introduction to textile chemistry, textile engineering and textile management, textiles, fibers and polymers, and to the textile-fiber-polymer-chemical-equipment-engineering industrial complex. Credit can not be obtained for both Text. 1100 and Text. 2701.

Text. 2100. Introduction to Fiber Science

3-0-3.

Introduction to natural and man-made fibers, fiber structure and physical properties including elasticity, recovery, moisture sorption and optical properties.

Text. 2101. Yarn Processing I

3-0-3. Prerequisite: Text. 2100.

Fundamental principles of processing natural and man-made staple fibers into yarn and basic properties of spun yarn.

Text. 2102. Yarn Processing II

3-0-3. Prerequisite: Text. 2101 or consent of department.

Alternate methods for producing yarns from continuous filament and staple fiber.

Text. 2180-1-2, 3480-1-2. Textile Manufacturing Processes I, II, III, IV, V and VI

0-3-1 each. Prerequisite: consent of department.

A course sequence giving the student hands-on experience in unit operations employed in textile manufacturing within a student operated enterprise.

Text. 2500. Survey of Apparel Manufacturing

3-0-3.

Apparel engineering and manufacturing from planning and receipt of raw materials to the distribution of finished garments.

Text. 2700. Survey of Polymer and Fiber Technology

3-0-3. Not open to textile students.

An introduction to the history, structure, properties, fabrication and use of polymers in the textile and related industries.

Text. 2701. Textile Industry Survey

3-0-3. Not open to textile students.

An overview of textiles, fibers and polymers and the associated complex of industries from raw materials to finished products including textile arts and textile management. Credit can not be obtained for both Text. 1100 and Text. 2701.

Text. 2702. Survey of Fibrous Materials

3-0-3. Not open to textile students.

A survey of natural and man-made fibers used in the textile industry.

Text. 3110. Woven Structures I

3-0-3. Prerequisite: Text. 2101.

The weaving process and woven fabric construction, design and properties are studied.

Text. 3111. Woven Structures II

3-0-3. Prerequisite: Text. 3110.

Dynamics, operating characteristics and economics of new weaving machines.

Text. 3112. Knit Fabrics

3-0-3. Prerequisite: Text. 2100.

A study of warp and weft knit fabric production, properties and design. Description of knitting

machines as related to fabric design and control of properties.

Text. 3113. Nonwoven Fabrics

3-0-3. Prerequisite: Text. 2100.

Chemically and mechanically bonded nonwoven fabrics, fabric formation processes, design and properties.

Text. 3120. Introduction to Textile Chemistry

3-0-3. Prerequisite: Chem. 1102.

An introduction to the study of organic chemistry as it applies to fibers, dyes, finishes and polymers.

Text. 3121. Structures of Organic Polymers

3-3-4. Prerequisite: Text. 3120 or consent of department.

A study of the chemical and physical structures of organic, fiber-forming polymers and the relationship of their structure to properties.

Text. 3400. Computer Applications in Textiles

2-3-3. Prerequisite: Phys. 2113 or consent of department.

Computer techniques are applied to textile engineering problems. A calculator assembler language introduces Fortran. Application is made of digital and analog interfaces to textile processes.

Text. 3483-4-5. Problems in Textile Management I, II and III

0-3-1 each. Prerequisite: Text. 3481 or concurrently.

Course sequence exposing the student to staff level problems of plant engineering, cost accounting, marketing, product development and personnel administration within a student operated enterprise.

Text. 3500. Jacquard Design and Weaving

2-3-3. Prerequisite: Text. 3110.

The designing of Jacquard patterns and the techniques involved in the transfer of design to the fabric.

Text. 3510. Materials Preparation, Pattern Analysis and Cutting in Garment Manufacture

3-0-3.

Methods, mechanics and analysis of materials preparation, pattern drafting and cutting in garment manufacture with emphasis on new methods and automation.

Text. 3511. Garment Assembly

4-0-4.

Formation and mechanics of seaming including thread properties, stitch formation, sewing machines, heat sealing and ultrasonic, radio frequency, infrared and adhesive bonding.

Text. 3512. Apparel Production, Planning and Engineering

4-0-4. Prerequisite: Text. 3510 or consent of department.

Analysis and design of apparel production from raw materials to finished product with emphasis on maximizing quality and productivity and minimizing time, cost and waste.

Text. 3700. Survey of Fiber Processing

3-0-3. Prerequisite: Text. 2701 or 2702. Not open to textile students.

A survey course in yarn manufacturing covering principles of processing natural and synthetic fibers.

Text. 3701. Survey of Fabric Production

3-0-3. Prerequisite: Text. 2701 or 2702. Not open to textile students.

A survey of fabric assemblies including woven, knit, nonwoven and flexible composite structures. Discussion includes processing, design and mechanical behavior.

Text. 3702. Survey of Dyeing and Finishing of Textile Materials

3-0-3. Prerequisite: Text. 2701 or 2702. Not open to textile students.

Dyeing and finishing of textile materials made from natural and synthetic fibers.

Text. 3750. Elementary Heat and Mass Transfer

3-0-3. Prerequisite: Math. 2308, Phys. 2123, M.E. 3720.

Unit operations of chemical engineering emphasizing applications to fibers and textiles. Also taught as Ch.E. 3750.

Text. 4100. Textile Management Decision Making

2-3-3. Prerequisite: senior standing.

Students practice making management decisions using computer simulations of textile manufacturing operations in a competitive market.

Text. 4200. Fiber Science

3-0-3. Prerequisite: Phys. 2121 or 2111.

The physical structure and properties of fibers are examined and related to end-use performance.

Text. 4201. Mechanics of Fibrous Structures I

3-0-3. Prerequisite: Text. 4200 or consent of department.

Yarn processing with emphasis on relationships between fiber properties and yarn properties.

Text. 4202. Mechanics of Fibrous Structures II

3-0-3. Prerequisite: Text. 4201 or consent of department.

Processes, properties and mechanics involved in the manufacture of woven and knitted fabrics.

Text. 4203. Mechanics of Fibrous Structures III

3-0-3. Prerequisite: Text. 4201 or consent of department.

Investigation of production processes, structures and properties of adhesive and mechanically bonded nonwoven fabrics and fiber reinforced materials.

Text. 4204. Chemical Processing of Textile Materials

3-0-3. Prerequisite: Text. 4751 or consent of department.

Chemical principles involved in the processing of textile materials.

Text. 4300. The Chemistry and Chemical Processing of Fibers and Textiles I

3-0-3. Prerequisite: Text. 3121 or 4751.

The structure and purification of natural and synthetic fibers with emphasis on the relationship of fiber structure and behavior during chemical processing.

Text. 4301. The Chemistry and Chemical Processing of Fibers and Textiles II

3-3-4. Prerequisite: Text. 3121 or 4751.

The dyeing and finishing of textile materials with emphasis on the relationship of fiber structure and response of textiles to these chemical and mechanical processes.

Text. 4310. Textile Instrumental Analysis

2-3-3. Prerequisite: consent of department.

The theory and practice of modern instrumental methods as used in the analysis of textile chemicals with emphasis on spectroscopy, chromatography, colorimetry and differential thermal analysis.

Text. 4400. Seminar

1-0-1. Prerequisite: senior standing.

Presentations by invited speakers on new developments in textiles, job opportunities and graduate education.

Text. 4401. Introduction to Textile Literature

1-0-1. Prerequisite: senior standing.

Sources of textile information and an introduction to search techniques for the textile information system.

Text. 4410. Alternate Materials for Structural Systems

3-0-3. Prerequisite: Phys. 2113, E.S.M. 3702.

The performance requirements of structural subsystems are examined and the relative merits of fibrous materials in these applications evaluated.

Text. 4420. Analysis of Textile Materials

3-3-4. Prerequisite: Text. 4200, 3121 or consent of department.

The methods used in the textile industry for assessing the effects of process variables on the end use performance of textile products are examined.

Text. 4480. Problems in Production Supervision

0-3-1. Prerequisite or corequisite: Text. 3485.

Supervision of the student

operated enterprise production operations. Solving day to day problems in logistics, personnel relations and manufacturing technology.

Text. 4481. Advanced Problems in Textile Management

0-3-1. Prerequisite: consent of department.

Supervision of one of the student operated enterprise's staff level departments.

Text. 4482. Product Innovation

0-3-1. Prerequisite: consent of department.

The student is part of a small entrepreneurial team developing new products for the student operated enterprise.

Text. 4483. Special Problems in Textile Industrial Operations

0-6-2. Prerequisite: Text. 3702 or consent of department.

Available to textile and non-textile students who want to engage in special projects which involve the personnel or facilities of the student operated enterprise.

Text. 4500. Technology of Carpet Manufacturing

3-0-3.

A study of materials and production systems used in carpet manufacturing. Carpet performance characteristics, dyeing, back-coating and non-woven carpet manufacturing methods are examined.

Text. 4502. Fiber Reinforced Materials

3-0-3. Prerequisite: consent of department.

Principles and engineering behavior of flexible and rigid fiber reinforced composites. Topics include influence of matrix, interface and voids, fabrication, fracture and

fatigue characterization, evaluation of specific composite systems.

Text. 4503. Science of Color

3-0-3. Prerequisite: Chem. 1102, Phys. 2113 or consent of department.

The physical, chemical and biological principles involved in perception, measurement and specification of color.

Text. 4504. Fiber Extrusion, Drawing and Texturing

3-0-3. Prerequisite: Text. 3121, 4751 or consent of department.

Rheology, mechanics, energetics, kinetics, phase transitions and polymer structure in fiber formation by melt, dry, wet and reactive spinning and drawing and texturing of fibers.

Text. 4505. Structure and Mechanics of Knit Fabrics

3-0-3. Prerequisite: Text. 3112 or consent of department.

The basic geometrics of fabrics produced by warp and weft knitting, overall physical properties of knit fabrics and fabric stress distribution.

Text. 4750. Polymer Science and Engineering I

3-0-3. Prerequisite: Chem. 1102, Phys. 2113 or consent of department.

An introduction to the chemistry and structure of polymers. Polymerization processes, major polymer systems and methods of identification of polymers are presented. Also taught as Ch.E. 4750.

Text. 4751. Polymer Science and Engineering II

3-0-3. Prerequisite: Text. 4750 or Ch.E. 4750.

An introduction to the physical states and transitions, fabrication

processes and mechanical properties of polymers. Also taught as Ch.E. 4751.

Text. 4752. Polymer Science and Engineering Laboratory

0-3-1. Prerequisite: Text. 4751 or Ch.E. 4751.

Experiments in polymerization, processing and property evaluation of polymers. Also taught as Ch.E. 4752.

Text. 4753. Survey of Pulp and Paper Technology

3-0-3.

The mechanical systems used in paper manufacture. Chemistry of pulp preparation and non-fibrous additives. Also taught as Ch.E. 4753.

Text. 4800-1-2. Special Topics

3-0-3 each. Prerequisite: consent of department.

Studies of topics of current interest and concern to the textile industry.

Text. 4900-1. Special Problems

Credit to be arranged. Prerequisite: consent of department.

Special problems involving analytical and/or experimental investigations in the field of textiles.

Text. 6200. Physical Methods of Investigating Textiles

3-6-5. Prerequisite: I.Sy.E. 3749, Text. 4420 or consent of department.

Study of modern techniques and instrumentation for the evaluation of physical properties of fibers, yarns and fabrics.

Text. 6201. Process Control in the Textile Industry

3-0-3. Prerequisite: Text. 6200 or consent of department.

Computer techniques are applied to problems in scheduling

production equipment and in control of quality, inventories and production. Topics include interfacing, costs, programming.

Text. 6210. Dynamics of Fiber Processing Systems I

3-0-3. Prerequisite: Text. 4200, 4201 or consent of department.

The dynamic interaction of fibers and fiber assemblies during processing is examined. The effects of fiber and bundle properties on processing variables are analyzed.

Text. 6211-2. Dynamics of Fiber Processing Systems II, III

3-0-3 each. Prerequisite: Text. 6210 or consent of department.

The dynamics of fabric forming mechanisms are examined. Weaving, knitting, sewing, heating and drying are typical processes which are considered.

Text. 6220-1. Problems in Fiber Processing Systems I, II

0-6-2 each. Prerequisite: Text. 6210.

Principles of forming various textile structures are demonstrated and verified in laboratory work.

Text. 6300. Preparation and Reactions of Polymers

3-0-3. Prerequisite: Text. 4750, 4751.

A detailed treatment of the reactions involved in the synthesis of both man-made and natural polymers including preparative and degradative reactions in polymer systems.

Text. 6320. Fundamental Aspects of Dyeing Processes

3-0-3. Prerequisite: Text. 4301, 4751 or consent of department.

Models required for the interpretation of the dyeing behavior of textile materials are examined in

order to provide useful semi-quantitative descriptions of dye processes.

Text. 6321. Chemical Technology of Stabilization Processes

3-0-3. Prerequisite: Text. 4301, 4751 or consent of department.

A comprehensive treatment of finishing processes used in the textile industry to impart desirable end-use performance characteristics to textile materials.

Text. 6750. Polymer Structure and Physical Properties I

3-0-3. Prerequisite: Text. 4751 or Ch.E. 4751 or consent of department.

Morphology and structure, linear and nonlinear viscoelasticity, anisotropic mechanical properties and yield and fracture behavior of polymers with applications to textile fibers and plastic products. Also taught as Ch.E. 6750.

Text. 6751. Polymer Structure and Physical Properties II

3-0-3. Prerequisite: Text. 6750 or Ch.E. 6750.

Structure-property relationships of elastomers, reinforced plastics, fibers, foams and natural polymers emphasizing proteins and the composite nature of all polymers and polymeric materials. Also taught as Ch.E. 6751.

Text. 7000. Master's Thesis

Text. 7210. Recent Advances in Textile Manufacturing

3-0-3. Prerequisite: consent of department.

A detailed review of significant new processes, techniques and machines in the textile industry.

Text. 7220. Fiber Mechanics

3-0-3. Prerequisite: Text. 4751 or consent of department.

The tensile, compressive, bend-

ing and torsional response of fibers. Fiber anisotropy and linear and nonlinear time dependent response are studied.

Text. 7221. Mechanics of Linear Assemblies

3-0-3. Prerequisite: Text. 4202 or consent of department.

The tensile, bending and torsional response of continuous filament, staple and blended singles yarns, the tensile response of plied yarns, cords and ropes, the tensile response of braided cords.

Text. 7222. Mechanics of Planar Assemblies

3-0-3. Prerequisite: Text. 7221.

A state-of-the-art study of woven, knit and nonwoven fabric mechanics.

Text. 7311. Polymer Degradation

3-0-3. Prerequisite: Text. 4750, 4751 or consent of department.

A study of the physical and chemical changes in polymeric materials exposed to hostile environments during processing and use.

Text. 7312. Dye Synthesis

3-3-4. Prerequisite: consent of department.

The industrial chemistry of dyes and their intermediates is covered. Structure is related to color, fastness and affinity. Lapworth nomenclature and recent patents are surveyed.

Text. 7750. Surface and Solution Properties of Polymers

3-0-3. Prerequisite: consent of department.

Study of plasticized polymers, solutions and colloids: sorption, polymer characterization, interfacial phenomena and coagulation using thermodynamics, statistical mechanics, information and fluctuation theories and relaxation methods. Also taught as Ch.E. 7750.

Text. 7751. Energetics

3-0-3. Prerequisite: consent of department.

Energetics applied to polymers and fibers using Newtonian mechanics, thermodynamics, statistical thermodynamics and quantum mechanics to relate macroscopic and molecular descriptions of processes and materials.

Text. 7752. Kinetics

3-0-3. Prerequisite: consent of department.

Kinetics applied to polymers and fibers including fluid flow, viscoelasticity, heat transfer, diffusion, electrical conductivity, rates of chemical reactions and phase changes and irreversible thermodynamics.

Text. 7753. Polymer Flow

3-0-3. Prerequisite: Text. or Ch.E. 6750 or consent of department.

The fluid mechanics, heat transfer and mixing of non-Newtonian fluids. Experimental methods for characterizing fluids and the extrusion of polymer melts are emphasized.

Text. 7999. Preparation for Doctoral Qualifying Exams

Text. 8000-1-2. Seminar

1-0-0 each.

Text. 8100-1-2. Special Topics in Textile Science and Engineering

3-0-3 each. Prerequisite: consent of department.

Topics of current interest in textile science and engineering.

Text. 8500-1-2. Special Problems in Textiles and Textile Engineering
Credit to be arranged.

Text. 9000. Doctoral Thesis

6/ Rules and Regulations



TECH

Student Rules and Regulations

The Committee on Student Rules and Regulations: H. R. Hunt, chairman, S. L. Dickerson, James E. Dull, F. E. Roper, J. W. Walker.

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I. General

These regulations are intended to set forth the requirements of the faculty to the end that a large student body may live and work together harmoniously with a minimum of friction and misunderstanding. Each student is expected to be a law-abiding citizen and to obey the laws of the City of Atlanta, Fulton County, the State of Georgia and the United States.

II. Responsibility For Notices

Every student will be required to have a box in the post office of the Georgia Institute of Technology which will be his official address, and he is expected to check this box each school day. Students are also expected to be aware of the contents of the general notices which appear in *The Technique*.

Change of address. Students are responsible for reporting changes of residential address, within one week's time, to the Office of the Registrar.

III. Attendance

A. General

1. Classes begin at five minutes after the hour and end at five minutes before the hour.
2. If an instructor should be late in meeting his class, the students shall wait for him until twenty minutes after the hour. If the instructor has not arrived by that time, they may leave unless specifically notified to await his arrival.

B. Class attendance

There are no formal institutional regulations regarding class attendance at the Georgia Institute of Technology. The resources of the institute are provided for the intellectual growth and development of the students who attend. A schedule of courses is provided for the students and faculty to facilitate an orderly arrangement of the program of instruction. The fact that classes

are scheduled is evidence that attendance is important and students should, therefore, maintain regular attendance if they are to attain maximum success in the pursuit of their studies.

It is recognized that the degree of class attendance may vary with the student, the instructor or the course. It is also recognized that, on occasions, it may be necessary for the student to be absent from scheduled classes or laboratories for personal reasons. On such occasions, all matters related to the student's absences, including the making up of work missed, are to be arranged between the student and the instructor.

All instructors will, at the beginning of each quarter, make a clear statement to all their classes regarding their policies in handling absences. Instructors will also be responsible for counseling with their students regarding the academic consequences of absences from their classes or laboratories.

Students must not be absent from announced quizzes, laboratory periods or final examinations unless the reasons for the absences are acceptable to the instructors concerned. Students should also understand that they are responsible for all material covered during their absences and that they are responsible for the academic consequences of their absences.

Students who are absent because of participation in approved institute activities (such as field trips and athletic events) will be permitted to make up the work missed during their absences. Approval of such activities will be granted by the student academic and financial affairs committee of the academic senate and statements of the approved absences may be obtained from the Office of the Registrar.

C. Absence from city

Students who leave the city for more than four days, except for official school holidays, must inform the dean of students before their departure.

IV. Grades

Final grades are reported to the registrar at the end of each term. The grades for completed courses used in the calculation of scholastic average are the following.

- A—excellent (4 quality points)
- B—good (3 quality points)
- C—satisfactory (2 quality points)
- D—passing (1 quality point)

F—failure, must be repeated if in a required course (no quality points)

The following grades will be used in the cases indicated and will not be included in the calculation of scholastic average.

S—satisfactory completion of a course taken under pass-fail or of a course in which no other letter grade may be assigned.

U—unsatisfactory completion of a course taken under pass-fail or of a course in which no letter grade may be assigned and must be repeated if in a required course.

V—assigned when the course has been audited. No credit given. Implies no academic achievement on the part of the student and cannot be changed to W or serve as the basis for credit by examination at any future date.

The following grades will be used in the cases indicated.

I—incomplete. Assigned when a student is incomplete in some part of the course for reasons deemed satisfactory by the instructor, or is absent from the final examination. If the student's record is so poor as to preclude his passing, the instructor shall assign the grade of F.

W—out before the end of the fifth week. The student must have officially dropped the course with all required approvals. After the fifth week of the quarter, approval will not ordinarily be given. Courses in which the grade W has been assigned will not be included in computing the scholastic average. The grade W is also assigned in cases where the student officially withdraws from school before the second week preceding the end of the quarter. Students who withdraw from school and receive all grades of W will not ordinarily be permitted to re-enroll the next succeeding quarter.

Errors in grades must be reported to the Office of the Registrar immediately. In general, no changes will be made after the end of the student's next quarter in residence.

V. Deficiencies

A. General

1. A student who has received a grade of I or F in a course has a deficiency in the course.
2. A student whose final grade is F has a failure in that course. He must repeat and pass the course in class before credit will be allowed. (See B.4. below)

B. Removal of deficiencies

1. An incomplete in a course must be removed and the grade change reported to the registrar not later than the end of student's next quarter of residence.
2. The grade of I will not be counted in the computation of the

student's point average at the end of the quarter in which he received the grade, nor in any quarters immediately following in which he is not enrolled. If the I is not removed and the change of grade reported by the end of the student's next quarter in residence, the grade of I will remain as part of the student's permanent record and be counted thereafter as an F in the computation of point average.

3. A student who has a failure in a required course must schedule that course the next time it is offered while he is in residence.

4. A senior who has a single deficiency between him and graduation will be permitted one reexamination not later than 72 hours before commencement exercises and thereafter one examination per annum until the deficiency is removed, with the dates of the annual periods beginning 30 calendar days after the end of the final quarter of residence. The reexamination will be graded S or U and grade so recorded. The previously assigned F will remain a part of the record.

5. A senior who has otherwise completed all requirements for graduation and who has an incomplete in laboratory work taken during his final quarter in residence may remove the incomplete at the convenience of the department of instruction concerned.

VI. Scholastic Regulations

A. General

1. Academic standing is based on the quarter credit hour system. One quarter credit hour corresponds to one hour per week of classroom work for a quarter or to three clock hours of laboratory work per week for a quarter.

2. Quality points are assigned as follows.

For each quarter credit hour with a grade of

- A—4 points
- B—3 points
- C—2 points
- D—1 point
- F—no points

B. Classification of students

1. Undergraduate students shall be classified at the end of each quarter by the Office of the Registrar on the basis of the number of quarter credit hours they have passed in accordance with the following schedule.

- freshman—0-45 credit hours
- sophomore—46-90 credit hours
- junior—91-136 credit hours
- senior—137-to graduation

A student who has completed all requirements for a particular classification as defined by his major department may petition for reclassification through his major department.

2. Students scheduled for twelve credit hours or more are classified as full-time students.

C. Change of major

Students, by filing the required form, will be permitted free transfer between schools during their first quarter at Georgia Tech.

Thereafter, by filing the required form, free transfer will be permitted if the student is not on academic warning or probation and not subject to disciplinary action. Students not entitled to free transfer may transfer at the discretion of the school they wish to enter.

D. General requirements

The institute reserves the right to drop from the rolls at any time a student whose record in scholarship is unsatisfactory. The following specific regulations are in addition to this general ruling.

E. Scholastic standing

1. Scholastic average. The scholastic standing of a student shall be determined by his scholastic average calculated as the ratio of the total number of quality points earned to the total number of quarter credit hours in which a final grade has been assigned.

2. Dean's list. The institution encourages excellence in scholarship and gives official recognition to students whose work is superior by publishing the dean's list at the end of each academic quarter. The dean's list includes all students who have, during the preceding quarter, made an academic average of 3.0 or higher, carried a load of at least 12 hours of course work on a credit basis and are not on academic warning or probation or subject to any disciplinary action.

3. Satisfactory scholarship.

(a) A scholastic average of 2.0 is the minimum satisfactory scholastic average except for freshmen for whom the requirement is 1.7 and for sophomores for whom the requirement is 1.9.

(b) A student whose scholastic average for any quarter is 1.0 or below may be referred to the undergraduate curriculum committee, which may place the student on academic probation or drop him regardless of his previous record if such action is deemed advisable.

4. Good academic standing. A student not on academic probation is in good academic standing.

5. Academic warning. A student who has an overall scholastic average below the minimum satisfactory scholarship requirement, or whose scholastic average for work taken during any quarter is below this requirement, shall be placed on academic warning and shall be limited to a maximum load of 18 credit hours.

6. Academic probation. A student on academic warning whose scholastic average is below the minimum satisfactory scholarship requirement for any quarter shall be placed on academic probation and shall be limited to a maximum load of 15 credit hours.

7. Dismissal for unsatisfactory scholarship.

a. A student on academic probation whose scholastic average for the quarter of probation is below the minimum satisfactory scholarship requirement and whose overall scholastic average is below the minimum satisfactory scholarship requirement shall be dismissed for unsatisfactory scholarship and dropped from the rolls.

b. The record of a student on academic probation whose overall scholastic average is satisfactory but whose quarter average is unsatisfactory may be reviewed by the undergraduate curriculum committee, which may dismiss the student or continue him on academic probation.

8. Academic review. A student who normally would be dropped from the rolls for academic deficiencies but appears from the record not to have completed the quarter may be placed on academic review. This is a temporary standing which makes the student ineligible for registration. If no acceptable explanation is given within a reasonable time, the standing is changed to drop.

9. Part-time students. These regulations do not necessarily apply to students receiving grades in less than twelve credit hours. The academic standing of these students may be determined by the undergraduate curriculum committee based on individual merit in each case.

F. Readmission

1. A student who for any reason has remained out of school one or more quarters excluding the summer quarter must apply for readmission. This application, with any pertinent supporting information, must be submitted to the registrar at least 20 days before the registration date for the quarter for which admission is requested.

2. A student who is dropped for unsatisfactory scholarship will ordinarily not be readmitted, and in no case shall his application for readmission be considered unless he has remained out of the institute for one regular quarter. (The summer session is considered here to be a regular quarter.) Course work pursued at

another institution after dismissal from Georgia Tech for unsatisfactory scholarship may be considered in evidence of readmissibility. If readmitted, a student will not necessarily be given transfer credit for work taken at another institution after dismissal from Georgia Tech for unsatisfactory scholarship. In no case will credit be allowed (except by examination) for courses completed at another institution that have previously been failed at Georgia Tech.

3. A student who has been dropped a second time for unsatisfactory scholarship will not be readmitted unless approved by the undergraduate curriculum committee.

G. Exceptions

Exceptions to the scholastic regulations may be made by the undergraduate curriculum committee whenever a consideration of the student's complete record indicates that the application of a specific regulation will result in injustice.

VII. Scheduling

1. Each student is strongly advised each quarter to schedule all prerequisite courses possible, and should schedule all other back courses before scheduling any advanced course.

2. In dropping courses from his schedule, a student must retain back courses in preference to advanced courses, unless permission is otherwise obtained from his school director.

3. The scheduling of back courses is the responsibility of the student, and he will be held accountable therefor.

4. The normal load scheduled by an undergraduate student in good standing may not exceed 21 credit hours. In exceptional cases a student may schedule up to 23 credit hours with permission of the undergraduate curriculum committee.

5. Auditing of courses will be permitted to a regularly enrolled student who has obtained the approval of his adviser and of the departments concerned. Such courses count at full value in computing the student's load. No credit is granted for courses scheduled on an auditing basis, and students are not permitted to change to or from an auditing status except through the regular procedures for schedule changes. The grade for auditing is V (visitor) and this grade should at no time be changed to a W on the basis of the auditor's attendance in the course. The grade of V will have no effect upon the student's grade point average and students will not be permitted to receive credit at any future date for their participation in a course as an auditor.

6. No course may be repeated for course credit toward a degree in which the student has been assigned a grade of C or better.

VIII. Midterm Deficiency Reports

At the end of the sixth week of each quarter instructors will report to the Office of the Registrar the names and grades of all students in freshman (1000 series) courses whose work is not passing at that time.

IX. Examinations

A. General

All reexaminations, examinations for advanced standing and special examinations must be authorized by the registrar before being scheduled.

B. Examinations for advanced standing

1. A student who offers satisfactory evidence that he is qualified to do so may receive credit for a course by examination. Such an examination is called an examination for advanced standing.
2. Examinations for advanced standing must be authorized by the registrar upon the recommendation of the department of instruction in which the course is offered.
3. An examination for advanced standing will be reported with an S or U grade. Neither grade will be included in the calculation of the scholastic average.
4. Examinations for advanced standing will ordinarily be offered during the week of final examinations.
5. For the privilege of taking an examination for advanced standing, a student will be charged the appropriate fee.
6. A student will not be allowed to take an examination for advanced standing in a given course more than twice.

C. Examinations for degree candidates

Students who are candidates for a degree will be exempted from final examinations at the end of the quarter immediately preceding commencement.

D. Regulations covering final examinations

A student reporting to a final examination room more than fifteen minutes after the hour shall not be allowed to take the examination, unless he can present a satisfactory explanation to the instructor conducting the examination. If unable to present an explanation satisfactory to the instructor, he shall receive an I.

X. Degrees

A. Regulations concerning degrees

1. To be considered for admission to candidacy for a degree, a student must make a formal petition for the degree during the quarter preceding his final quarter in residence.
2. To be a candidate for a degree, an undergraduate student must have passed all courses required for the degree, must have a scholastic average for his entire academic program of at least 2.0, and must have done creditable work in his departmental courses so as to merit the recommendation for the degree by the director and faculty of his school.
3. A student, with the approval of his school of specialization, may satisfy the requirements for an undergraduate degree by meeting all of the requirements listed in any one of the catalogs in effect during the period of his enrollment in the institute. A given catalog is in effect for a given student only if the student's date of matriculation is prior to the ending date of the spring quarter shown in the calendar printed in the catalog concerned.
4. No student may be considered a candidate for a degree unless the final 50 credit hours required for the degree are earned in residence at Georgia Tech.
5. The diploma of a candidate for a degree shall bear the date of the commencement at which the degree is awarded.
6. For graduation with highest honor the minimum scholastic average shall be 3.6. For graduation with high honor the minimum scholastic average shall be 3.4. For graduation with honor the minimum scholastic average shall be 3.2. A student must have earned at least 100 credit hours at Georgia Tech to graduate with highest honor, with high honor or with honor.
7. No work may be counted toward a degree which has been completed more than ten years prior to the time at which the degree is to be awarded, unless this work is validated by an examination.

B. Second undergraduate degree

1. A student enrolled for a second undergraduate degree shall be classified an undergraduate student.
2. To be a candidate for a second undergraduate degree, a student must have the recommendation of the director of the school concerned and the approval of the undergraduate curriculum committee.
3. To obtain a second undergraduate degree, a student must complete all major required courses for the degree and earn credit for a total of at least fifty credit hours in excess of the requirement for any previous degrees earned.
4. All regulations outlined in section X.A. above must be followed by students completing second degrees.

XI. Conduct

A. Student Conduct Code

A student enrolling in the Georgia Institute of Technology assumes an obligation to conduct himself in a manner compatible with the institute's function as an educational institution. Actions considered inimicable to the institute and subject to discipline fall into the categories of academic and non-academic misconduct.

1. Academic Misconduct. Academic misconduct is any act or acts on the part of or in behalf of any student, which does or could improperly distort student grades or other student academic records. Students are prohibited from:

- a. possessing, using or exchanging written or verbal information not authorized by the instructor in the preparation of any essay, laboratory report, examination or other assignment included in an academic course,
- b. unauthorized collaboration with, or substitution for, a student in the commission of their academic requirements,
- c. submission of material which is wholly or substantially identical to that created or published by another person or persons, without adequate credit notation indicating the authorship (plagiarism),
- d. false claims of credit for work which has not been submitted by the claimant,
- e. alteration or insertion of any academic grade or rating so as to obtain unearned academic credit,
- f. willful falsification of a written or verbal statement of fact to a member of the faculty so as to obtain unearned academic credit, and
- g. forgery, alteration, or misuse of any institute document relating to the academic status of the student.

2. Non-Academic Misconduct. Non-academic misconduct includes the following specifically prohibited acts whenever, unless otherwise stated, such acts occur on institute owned or controlled property or institute related premises.

- a. Alcohol
 - (1.) Conspicuous or flagrant possession of alcoholic beverage.
 - (2.) Intoxication made manifest by boisterousness, rowdiness, obscene or indecent conduct or appearance, or vulgar, profane, lewd or unbecoming language.
 - (3.) Disorderly conduct associated with the use of alcoholic beverages.
- b. Physical Abuse of Other Persons
 - (1.) No student shall push, unjustifiably strike or physically assault, or otherwise intentionally threaten or endanger the per-

son of any member of the faculty, administration, staff or student body or any visitor to the campus.

c. Disorderly Conduct

(1.) Breach of the peace or obstruction or disruption of teaching, research, administration, disciplinary procedures or other institute activities, including its public service functions or other authorized activities.

(2.) Refusal to vacate a building, street, sidewalk, driveway or other facility when directed to do so by any properly identified institute faculty, administration or staff personnel while these are in the performance of their duties.

(3.) Lewd, indecent or obscene conduct or expression.

(4.) Failure to comply with instructions or directions of any properly identified faculty, administration or staff personnel while these persons are acting in the performance of their duties.

d. Drugs

Use, or possession (without valid medical or dental prescriptions), manufacture, furnishing, sales or any distribution of any narcotic or dangerous drug controlled by law. This provision is not intended to regulate alcoholic beverages, which are covered by section 2a.

e. Entry or Use of College Facilities

(1.) Unauthorized entry into any institute building, office or other facility, without authorization, or remaining in any building after normal closing hours.

(2.) Unauthorized use of any institute telephone facility or of any other institute facilities.

(3.) Possessing, using, making or causing to be made any key or keys for any institute facility without proper authorization.

f. False Information and Record Falsification

(1.) Furnishing false information to any institute official, or offering false statement in any institute disciplinary hearing.

(2.) Forgery, alteration or misuse of any institute document, record or identification.

g. Hazing

Any act which tends to occasion or allow physical or mental suffering in connection with rites or ceremonies of induction, initiation or orientation into institute life or into the life of any institute group or organization.

h. Repeated Violations

Repeated violations of these or other published rules or regulations of the institute, which cumulatively indicate an unwillingness or inability to conform to the standards of the institute for student life.

i. Safety

(1.) Intentionally false reporting of a fire, or that a bomb or

other explosive has been placed in any institute building or elsewhere on institute property.

(2.) Tampering with fire-fighting equipment, safety devices or other emergency or safety equipment.

(3.) Setting an unauthorized fire.

(4.) Possession of unauthorized fireworks, firearms, ammunition or dangerous weapons or materials.

(5.) Unauthorized sale, possession, furnishing or use of any incendiary device or bomb.

(6.) Use of smoking tobacco, in any form, in facilities or areas posted with "No Smoking" signs, or where smoking has been prohibited by any faculty member or other official.

j. Theft

(1.) Theft of property of the institute or property of a member of the institute community or campus visitor.

(2.) Unauthorized possession of institute property, or property of a member of the institute community or campus visitor.

k. Property Damage

Malicious or unauthorized damage or destruction to institute property, or property belonging to any member of the institute community or campus visitor.

l. Complicity

Knowingly act in concert with any other person to perform an unlawful act or to violate an institute regulation or policy.

m. Residence

Violation of rules governing residence in institute owned or controlled property (dormitories, family housing, fraternities, organizations, etc.).

n. Gambling

Playing of cards or any other games of skill or chance for money or other items of value.

o. Student Delinquencies – Financial, Records, Property

Failure to remit, return or submit financial obligations, property or records of the institute, within the time prescribed by the institute.

p. Law Violations and Off-Campus Violations of the Student Conduct Code Occurring Outside Institute-owned, or Controlled, or Related Premises

Violations, wherever they may occur of the conduct code, and/or the laws of the City of Atlanta, Fulton County, the state of Georgia or the United States, where the violative act creates a clear and present danger of material interference with the normal or orderly processes of the institute or its requirements of appropriate discipline.

q. Violations of the Student Motor Vehicle Regulations

Violations fall within the jurisdiction of the student traffic court.

r. Campus Disruption

Violation of the Regents Statement of Disruptive Behavior, the full text of which is given in Section C.

B. Disciplinary Administration

1. Disciplinary Procedures.

a. All acts of misconduct (excepting violations of motor vehicle regulations) on the part of students shall be reported to the dean of students, who is designated the principal administrator to enforce institute disciplinary measures as they pertain to student academic and non-academic misconduct.

b. The dean of students shall cause to be investigated alleged acts of student misconduct reported to him. He may appoint a staff member(s) to conduct an inquiry into alleged misconduct act(s) and the appointed member(s) shall recommend to the dean of students what further action, if any, might be initiated. When additional action is indicated, the dean of students shall notify the accused student(s) in writing. Cases of academic misconduct are referred to the student-faculty honor committee through the hearing body chairman. Cases of non-academic misconduct are referred to the graduate judiciary or undergraduate judiciary cabinet through the hearing body chairman.

c. When written notification is made by the dean of students to a student(s) for alleged violations of academic misconduct or non-academic misconduct, it shall contain a statement of the nature of the alleged or suspected misconduct, and state the section(s) of the conduct code the student(s) is alleged to have violated.

d. The dean of students or his authorized representative will normally confer with the accused student(s), and at this conference the student(s) may admit or deny the alleged violation, the student(s) may waive further hearing(s) and appeal(s) in writing and request that the dean of students take appropriate action, or he may request a hearing as specified in e, f or g below.

e. Cases of academic misconduct will normally be referred to the student-faculty honor committee, which shall hear and try cases involving academic misconduct on the part of any student(s).

f. Cases of serious non-academic misconduct which may result in suspension or expulsion will normally be referred to the graduate judiciary or undergraduate judiciary cabinet, which shall hear and try these cases. (This does not preclude possible legal actions by appropriate law enforcement agencies in those cases of non-academic misconduct in violation of federal, state or local law.)

g. If the case does not involve possible suspension or expulsion, the dean of students ordinarily shall make full disposition of

the case except that he shall at the request of the accused, or for good cause may, refer any case of non-academic misconduct to the graduate judiciary or undergraduate judiciary cabinet.

h. A student(s) accused of an act of academic misconduct or non-academic misconduct is encouraged to notify his/her parents or guardian of the charge(s). Parents or guardian will, if requested, be granted a conference with the dean of students prior to the hearing.

i. An accused student(s) will continue to attend classes and required institute functions until the hearing is held and a decision is rendered. Exceptions to this will be made when the student(s)' presence may create a clear and present danger of materially interfering with the institute's normal operations or the requirements of appropriate institute discipline. In such cases, the dean of students may impose temporary protective measures, including interim suspension, pending the hearing; such protective measure, if applied, will be without reasonably avoidable prejudice to the student(s).

2. Student-Faculty Honor Committee.

a. The student-faculty honor committee shall consist of four faculty members (of staggered terms 4, 3, 2, and 1 years – the faculty member with the longest service on the committee shall be chairman) and three students. The faculty members shall be members of the academic senate and shall be appointed by the president. In cases involving undergraduate students, the student members of the committee shall be currently enrolled, full-time, undergraduate students in good standing appointed by the student body president with the approval of the student council. In cases involving graduate students, the student members of the committee shall be currently enrolled, full-time graduate students in good standing who are appointed by the president of the graduate student body and approved by the graduate student senate.

b. The student-faculty honor committee shall hear all cases of alleged academic misconduct.

3. Student Judiciary.

a. The graduate judiciary shall consist of a graduate student chairman and six graduate student justices. The graduate student justices and chairman shall be currently enrolled, full-time graduate students in good standing who are appointed by the graduate student body president and approved by the graduate student senate. The graduate judiciary shall normally hear all cases of graduate student non-academic misconduct in which there is the possibility of suspension or expulsion of the accused student. The graduate judiciary shall have appellate jurisdiction in cases from the student traffic court involving graduate students.

b. The undergraduate judiciary cabinet shall consist of an undergraduate student chairman and ten undergraduate student justices. The undergraduate student justices and chairman shall be currently enrolled, full-time, undergraduate students in good standing who are appointed by the student body president and approved by the student council. The undergraduate judiciary cabinet shall normally hear all cases of undergraduate student non-academic misconduct in which there is a possibility of suspension or expulsion of the accused student. The undergraduate judiciary cabinet shall have appellate jurisdiction in cases from the student traffic court involving undergraduate students.

4. Procedural Rights of Accused.

a. A student(s) accused of an act(s) of misconduct and summoned to a hearing before the student-faculty honor committee, graduate judiciary or judiciary cabinet shall have the right to:

- (1.) be accompanied by an adviser of his choice,
- (2.) remain silent with no inference of guilt drawn therefrom,
- (3.) question the complainant,
- (4.) present evidence in his behalf,
- (5.) call pertinent witnesses in his behalf,
- (6.) cross-examine witnesses,

(7.) in undergraduate judiciary cabinet hearings the accused may challenge and unseat as many as four student justices (the chairman cannot be struck; a quorum of six student justices and the chairman must remain) and

- (8.) appeal.

5. Hearing Procedures.

a. The chairman of the hearing body shall set the date, time and place of the hearing, shall notify the members of the hearing body and summon all principals in the case (defendants and witnesses).

b. In cases referred to the student-faculty honor committee, graduate judiciary or undergraduate judiciary cabinet, the chairman shall notify the accused student(s) in writing at least three days in advance of the scheduled hearing. The written notification should, if reasonably possible, be hand-delivered; if not reasonably possible, notification should be by registered mail to the student's local address. The written notification should specify:

- (1.) The date, time and place of the hearing.

(2.) A statement of the nature of the alleged or suspected misconduct with which he is accused, with sufficient particularity to ensure opportunity to prepare for the hearing.

- (3.) Names of witnesses scheduled to appear.

c. Decisions of the hearing body shall be by majority vote. A quorum for the student-faculty honor committee shall consist of five members, three faculty members and two students. A quorum for the undergraduate judiciary cabinet shall consist of the chairman and six justices. (In appeals involving violations of student motor vehicle regulations, three student justices will constitute a quorum). A quorum for the graduate judiciary shall consist of the chairman and four justices.

d. Any member of the hearing body shall disqualify himself if his personal involvement in the hearing is of such a nature as to prejudice the case.

e. The hearings of the student-faculty honor committee, graduate judiciary and undergraduate judiciary cabinet shall ordinarily be closed except for the accused and his adviser and those directly involved; exceptions may be made at the discretion of the chairman. The hearing body may exclude any person who may be reasonably expected to interfere materially with the hearing or who does interfere materially with the hearing. Hearing body deliberations are closed to all but the hearing body members.

f. The hearing body shall make a tape recording and/or summary transcription of the proceedings.

g. The hearing body shall provide a brief written summary of each case with recommendations for appropriate disciplinary action to the dean of students and to the student(s) involved.

h. The dean of students will review the case and recommendations and implement disciplinary action.

6. Disciplinary Measures.

a. For violations of institute rules and regulations or for acts of student misconduct, academic or non-academic, the following disciplinary measures may be taken. (This list shall not be taken to be exhaustive and may be enlarged or modified to meet particular circumstances in any given case.)

(1.) Expulsion — permanent severance of the student's relationship with the institute.

(2.) Disciplinary suspension — temporary severances of the student's relationship with the institute for a specific period of time, though not less than one quarter.

A student expelled or suspended shall leave the campus and not visit the campus during the period of suspension or expulsion, except when on official school business. To violate this stipulation would affect adversely the student's chances for readmission.

(3.) Disciplinary probation — notice to the student that any further major disciplinary violation may result in suspension; disciplinary probation might also include either or both of the

following: the setting of restriction, the issuing of a reprimand or restitution. A student on disciplinary probation is not in good standing, and shall not be permitted to hold any elective or appointive office in extracurricular activities, or participate in any contest, performance or activity to which the general public is invited.

(4.) Reprimand

Oral reprimand – an oral disapproval issued to the student.

Letter reprimand – a written statement of disapproval to the student.

(5.) Restrictions – exclusion from enjoying or participating in:

(a.) Social activities

(b.) Identification card privileges

(6.) Fines

(7.) Restitution – reimbursement for damage to or misappropriation of property; this may take the form of appropriate service or other compensation.

(8.) Forced withdrawal – from the academic course within which the offense occurred without credit for the course.

(9.) Change in grade – for the course in which the offense occurred.

7. Appeal Procedures.

a. If an accused or an accuser is dissatisfied with the action taken by the dean of students, he may appeal the case in writing to the president of Georgia Tech within five days after the action about which there is a complaint.

b. The president, within five days, shall:

(1.) Refer the appeal to the student-faculty appeal board to review all facts and circumstances connected with the case and report their findings to the president within five days of the receipt of the appeal.

The student-faculty appeal board will consist of five faculty members (of staggered terms of 5,4,3,2 and 1 years – the faculty member with the longest service on the appeal board shall be chairman (the faculty members will be selected and appointed by the executive committee of the academic senate) and four currently enrolled, full-time students in good standing two undergraduate students of junior or senior standing and two graduate students who have been enrolled for at least one year. The graduate student members will be appointed by the graduate student body president with the approval of the graduate student senate. The undergraduate student members will be appointed by the student body president with the approval of the student council. A quorum will consist of three faculty and two students.

c. The president, within five days from the receipt of the com-

mittee's recommendation, shall make a decision in the case which shall be final so far as the institute is concerned.

d. The Board of Regents of the University System of Georgia is the final appellate authority for all cases involving students who have been suspended or expelled. Appeals made to the board of regents by students who have been suspended or expelled may only be made after appealing to the president of Georgia Tech, and such appeal must be made in writing to the executive secretary of the board of regents within ten days after the president's decision. Such shall recite all reasons for dissatisfaction with the previous decision.

C. Regent's Statement on Disruptive Behavior

The following is the policy of the board of regents regarding disruptive behavior in any institution of the university system. The rights, responsibilities and prohibitions contained in this statement are incorporated as a part of these regulations.

The Board of Regents of the University System of Georgia reaffirms its policies to support fully, freedom of expression by each member of the academic community and to preserve and protect the rights and freedom of its faculty members and students to engage in debate, discussion, peaceful and nondisruptive protests and dissent. The following statement relates specifically to the problem described below. It does not change or in any way infringe upon the board's existing policies and practices in support of freedom of expression and action. Rather, it is considered necessary to combat the ultimate effect of irresponsible disruptive and obstructive actions by students and faculty which tend to destroy academic freedom and the institutional structures through which it operates.

In recent years a new and serious problem has appeared on many college and university campuses in the nation. Some students, faculty members and others have on occasion engaged in demonstrations, sit-ins and other activities that have clearly and deliberately interfered with the regular and orderly operation of the institution concerned. Typically, these actions have been the physical occupation of a building or campus area for a protracted period of time or the use or display of verbal or written obscenities involving indecent or disorderly conduct.

These actions have gone beyond all heretofore recognized bounds of meetings for discussion, persuasion or even protest in that: (1) acquiescence to demands of the demonstrators is the condition for dispersal and (2) the reasonable and written direc-

tions of institutional officials to disperse have been ignored. Such activities thus have become clearly recognizable as an action of force, operating outside all established channels on the campus, including that of intellectual debate and persuasion which are at the very heart of education.

The board of regents is deeply concerned by this new problem. Under the Constitution of the State of Georgia, under all applicable court rulings and in keeping with the tradition of higher education in the United States, the board is ultimately responsible for the orderly operation of the several institutions of the university system and the preservation of academic freedom in these institutions. The board cannot and will not divest itself of this responsibility.

Of equal or even greater importance, such action of force as has been described above destroys the very essence of higher education. This essence is found in the unhampered freedom to study, investigate, write, speak and debate on any aspect or issue of life. This freedom, which reaches its full flowering on college and university campuses, is an essential part of American democracy, comparable to the jury system or the electoral process.

For these reasons and in order to respond directly and specifically to this new problem the board of regents stipulates that any student, faculty member, administrator or employee, acting individually or in concert with others, who clearly obstructs, disrupts or attempts to obstruct or disrupt any teaching, research, administrative, disciplinary, public service activity or any other activity authorized to be discharged or held on any campus of the University System of Georgia is considered by the board to have committed an act of gross irresponsibility and shall be subject to disciplinary procedures, possibly resulting in dismissal or termination of employment.

The board reaffirms its belief that all segments of the academic community are under a strong obligation and have a mutual responsibility to protect the campus community from disorderly, disruptive or obstructive actions which interfere with academic pursuits of teaching, learning, and other campus activities.

The board of regents understands that this policy is consistent with resolutions adopted by the American Association of University Professors in April 1968, by the Association of American Colleges in January 1968 and by the executive committee of the Association for Higher Education in March 1968 condemning actions taken to disrupt the operations of institutions of higher education. (Minutes, 1968-69, pp. 166-169).

XII. Withdrawal From School

A. General

1. No student under eighteen years of age will be allowed to withdraw from school before the official close of a quarter, unless he first presents, with his formal registration, written permission to this effect from his parents or guardian. A student over eighteen years of age may withdraw upon the submission of a formal resignation. A student who withdraws without notice is not entitled to an honorable dismissal.
2. A student withdrawing from school should obtain the proper forms from the Office of the Registrar and comply with the instructions therein.
3. Students who withdraw from school and receive all grades of W will not ordinarily be permitted to enroll the next succeeding quarter.
4. Requests for readmission must be filed with the registrar at least 20 days before the registration date of the quarter for which readmission is requested.

B. Exceptions

This regulation does not apply to those instances where a student has completed attendance for an official school quarter and does not register for the succeeding quarter.

XIII. Student Motor Vehicles

Students desiring to operate motor vehicles on campus are subject to all rules set forth by the student traffic court and the student motor vehicle regulations.

XIV. Medical Regulations

A. General

No student with a contagious disease may stay in a dormitory or fraternity house or attend class. Any illness with fever should be considered a contagious disease until checked by a physician. Every student is held individually responsible for reporting such illness immediately to the infirmary.

B. Health Information Record

Health information record and consent-for-treatment forms are mailed to students with the notice of their acceptance for enrollment. These forms are to be completed by the prospective student and his parents or guardians and mailed to the director of

health in sufficient time to be received prior to the date of initial registrations. After review of the health information record, the school physicians shall determine the qualifications for physical training. Any student who desires special consideration because of mental or physical disability should have his physician write an explanatory letter to the director of health giving full details of the disability and any desired limitations on physical activity. This letter is to be attached to the health information record. Any special examinations or reports needed to determine eligibility for enrollment or assignment are at the expense of the student, not the school.

C. Infirmary regulations

Students must conform to infirmary regulations, as posted in the infirmary, while confined as patients in the infirmary.

XV. Physical Education

All freshman students will be required to take physical education except the following who will be exempt: students not physically able; students twenty-one years of age or over on first admission to Georgia Tech; students who are over twenty-five years of age; veterans, who shall receive one quarter exemption for each full three months of active duty; transfer students who shall receive one quarter exemption for each quarter as a full-time student at another institution.

The director of health shall determine physical ability. The registrar shall determine all other exemptions. The undergraduate curriculum committee may grant exemptions in exceptional cases.

Students who are exempted for physical reasons from all or any one of P.E. 1010, 1020 or 1050 will be required to take P.E. 1040.

Students who are exempted because of age, military service or a transfer from another institution do not have to take P.E. 1040 and the hours required for physical education do not have to be made up with electives.

Female students must satisfactorily complete any three hours of physical education in order to complete their physical education requirements.

XVI. ROTC Regulations

A. General

1. Georgia Tech offers both the four-year and the two-year programs as provided for in the 1964 ROTC Vitalization Act.

2. The entire ROTC program at Georgia Tech is voluntary.

B. Basic course

1. Six hours of completed basic ROTC can be counted by the student toward his degree.
2. If the student elects to take basic ROTC but drops it before completing six credit hours he must make up the difference between the credit hours he has completed in ROTC and six hours.

C. Advanced course

Students who are selected for further training may enroll in the advanced course. The advanced course is a recognized elective in all schools at Georgia Tech to the extent that a maximum of nine hours of credit may be applied toward a degree.

XVII. General Student Activities

A. Participation

1. In order to be eligible for participation in extracurricular activities, a student must be enrolled in a degree program, in good standing, and carrying a schedule of at least six credit hours. (In addition, he must meet any further requirements stipulated by the student activities committee.)
2. During the first week of each quarter, a schedule of public performances to be sponsored by each student organization must be submitted to the dean of students for approval by the student academic and financial affairs committee.
3. In each quarter the weekend before final examinations is closed to extracurricular activities.

B. Social functions

All student organizations must take written application to, and receive permission from, the Office of the Dean of Students to hold a social function. Such requests must be submitted one week before the date of the activity. This permission must be received before making any agreement in connection with the function.

C. Student organizations

1. Any group of undergraduate students desiring to form an organization on the campus of the Georgia Institute of Technology must submit a written statement of the purposes of the proposed

organization, six copies of the constitution and a list of officers and members to the student council for its approval. If the student council approves these it shall forward them to the student activities committee, whose approval is also necessary. Academic senate approval will be granted by the acceptance of the minutes of the student activities committee. Subsequent revisions and amendments of the constitution must also be approved by the student council and the student activities committee.

2. A copy of the constitution of each student organization is to be filed with the Office of the Dean of Students. Periodic reports as requested by the Office of the Dean of Students are to be supplied. Failure to fulfill such requests will be cause for inactivation of the organization concerned.

3. All student organizations are subject to the social regulations of the Georgia Institute of Technology.

4. An annual review of each undergraduate student organization will be made by the student council and each graduate organization by the graduate student senate to determine its vitality and usefulness, its pursuit of its purposes, its observance of its constitution and the student rules and regulations and its compliance with all other relevant school rules and regulations. The conclusions about each organization will be transmitted to the student activities committee with a recommendation to continue, to place on probation for one year or to inactivate the organization.

D. Fraternity rules

1. In order to be eligible for initiation, a person must be a bona fide student in good standing, carrying a schedule of at least 12 hours.

2. The initiation of any individual must be registered with and approved by the dean of students prior to the initiation.

3. The individual must meet all Georgia Tech IFC requirements concerning initiation.

4. All fraternities are subject to the rules established by the Georgia Tech IFC.

E. Eligibility for class rings

A student may purchase a class ring during or after the second quarter of the school year if at that time, he has reached the second quarter of junior classification.

F. Athletic regulations

1. In order to be eligible for athletic competition, a student must be a bona fide student in good standing, carrying a schedule of at least 12 credit hours, and making satisfactory progress towards a

degree. (In addition he must meet any further requirements of the NCAA. See athletic director for rules.)

2. No student may be excused from regularly scheduled classes for athletic practice.

3. No student may participate in more than two sports in inter-collegiate competition in any school year, except by permission of the dean of students. Being manager or assistant manager is counted as participation within the meaning of this rule.

XVIII. Exceptions

Where appeals are not otherwise specified in this document, exceptions to the regulations may be made by the undergraduate curriculum committee upon petition by the student and recommendation of the student's school or the department concerned. (See also Sec. VI Par. G.) Blanket exceptions for groups of students which have the effect of amending these regulations shall be referred to the academic senate for approval.

All regulations adopted before this time are hereby superseded.

Definition of Legal Residence

1. (a) If a person is 18 years of age or older, he or she may register as a resident student only upon a showing that he or she has been a legal resident of Georgia for a period of at least twelve months immediately preceding the date of registration. (b) No emancipated minor or person 18 years of age or older shall be deemed to have gained or acquired in-state residence status for fee purposes while attending any educational institution in this state, in the absence of a clear demonstration that he or she has in fact established legal residence in this state.

2. If a person is under 18 years of age, he or she may register as a resident student only upon a showing that his or her supporting parent or guardian has been a legal resident of Georgia for a period of at least twelve months immediately preceding the date of registration.

3. A full-time faculty member of the University System and his or her spouse and dependent children may register on the payment of resident fees even though he or she has not been a legal resident of Georgia for the preceding twelve months.

4. Non-resident graduate students who hold teaching or research assistantships requiring at least one-third time service may register as students in the institution in which they are employed on payment of resident fees.

5. Full-time teachers in the public schools of Georgia and their

dependent children may enroll as students in the University System institutions on the payment of resident fees, when such teachers have been legal residents of Georgia for the immediately preceding nine months, were engaged in teaching during such nine month period and have been employed to teach full-time in the public schools of Georgia during the ensuing school year.

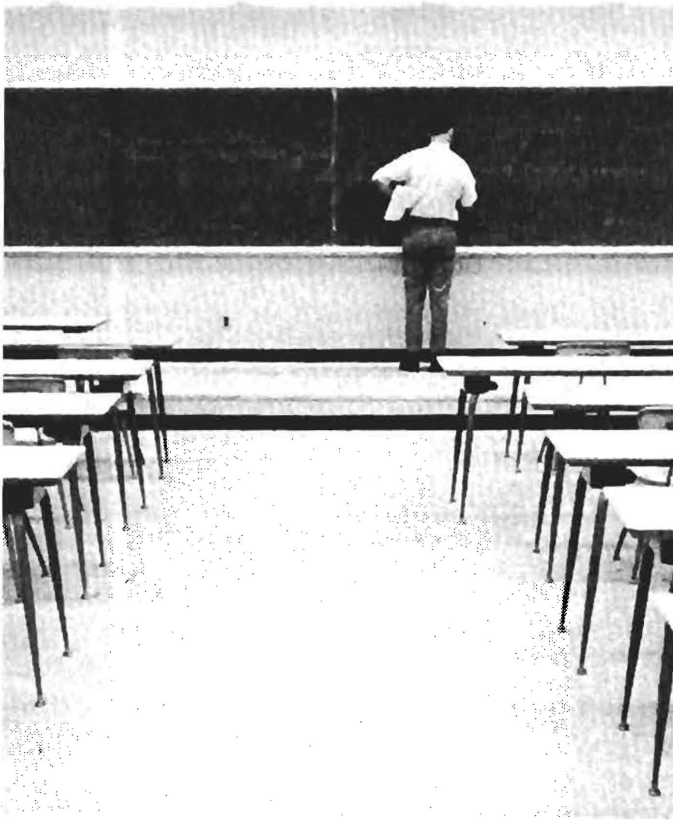
6. All aliens shall be classified as non-resident students; however, an alien who is living in this country under a visa permitting permanent residence shall have the same privilege of qualifying for resident status for fee purposes as a citizen of the United States.

7. Foreign students who attend institutions of the University System under financial sponsorship of civic or religious groups located in this state may be enrolled upon the payment of resident fees, provided the number of such foreign students in any one institution does not exceed the quota approved by the board regents for that institution.

8. If the parents or legal guardian of a minor changes his or her legal residence to another state following a period of legal residence in Georgia, the minor may continue to take courses for a period of twelve consecutive months on the payment of resident fees. After the expiration of the twelve month period the student may continue his registration only upon the payment of fees at the non-resident rate.

9. In the event that a legal resident of Georgia is appointed as guardian of a non-resident minor, such minor will not be permitted to register as a resident student until the expiration of one year from the date of court appointment, and then only upon proper showing that such appointment was not made to avoid payment of the non-resident fees.

7/ Administration, Faculty and Staff



TECH

Administration

Board of Regents

Georgia Institute of Technology is one of the educational institutions constituting the University System of Georgia. The University System is governed by a 15-man board of regents, the members of which are appointed to seven-year terms by the Governor of Georgia. The members of the board of regents are listed below.

Lamar R. Plunkett, Bowdon	State-at-Large
Jesse Hill, Jr., Atlanta	State-at-Large
Milton Jones, Columbus	State-at-Large
*John A. Bell, Jr., Dublin	State-at-Large
Sam A. Way, III, Hawkinsville	State-at-Large
Mrs. Hugh Peterson, Sr., Ailey	First District
John I. Spooner, Donalsonville	Second District
John H. Robinson, III, Americus	Third District
John R. Richardson, Conyers	Fourth District
W. Lee Burge, Atlanta	Fifth District
David H. Tisinger, Carrollton	Sixth District
James D. Maddox, Rome	Seventh District
**Charles A. Harris, Ocilla	Eighth District
P. R. Smith, Winder	Ninth District
Carey Williams, Greensboro	Tenth District

*Vice Chairman

**Chairman

Chancellor of the University System and His Administrative Staff

Chancellor George L. Simpson, Jr. is the chief administrative officer of the university system and the chief executive officer of the board of regents. Members of his administrative staff are the following.

John O. Eidson, *vice chancellor*

John W. Hooper, *associate vice chancellor*

Henry G. Neal, *executive secretary*

Shealy E. McCoy, *vice chancellor—Fiscal Affairs and treasurer*

James E. Boyd, *vice chancellor—Academic Development*

Frank C. Dunham, *vice chancellor—Construction and Physical Plant*

Mario J. Goglia, *vice chancellor—Research*

Howard Jordan, Jr., *vice chancellor—Services*
 Harry B. O'Rear, *vice chancellor—Health Affairs*
 James L. Carmon, *assistant vice chancellor—Computing Systems*
 Haskin R. Pounds, *assistant vice chancellor*
 Mrs. Hubert L. Harris, *assistant vice chancellor—Personnel*
 Robert M. Joiner, *assistant vice chancellor—Communications*
 Harry H. Murphy, Jr., *director, Public Information*
 C. C. Murray, *director, Interinstitutional Programs in International Affairs*

Institutional Administration

Office of the President

The president of Georgia Institute of Technology is Joseph Mayo Pettit, Ph.D. President Pettit reports to the chancellor of the University System of Georgia. The other principal administrative officers of the institute are listed below.

Office of the Vice-president for Academic Affairs

Vernon Crawford, Ph. D., *vice-president, Academic Affairs*
 Walter L. Bloom, M.D., *associate vice-president, Academic Affairs*

Office of the Vice-president for Research

Thomas E. Stelson, D.Sc., *vice-president, Research*

Office of the Vice-president for Business and Finance

Ewell Barnes, B.S., *vice-president, Business and Finance*
 Milton W. Bennett, *acting director, Research Administration*
 Bessie J. Bailey, *senior accountant*
 Billy H. Atcheson, *supervisor of accounting and budgets, Engineering Experiment Station*
 Daniel B. Conner, B.B.A., *senior accountant, Southern Technical Institute*
 Frank H. Huff, B.B.A., C.P.A., *director, Financial Affairs*
 C. Evan Crosby, B.S., *associate director, Financial Affairs*
 H.T. Marshall, A.N., LL.B., C.P.A., *director, Financial Systems and Control*
 Walter D. Adcock, M.B.A., *associate director, Financial Systems and Control*
 Charles R. Johnson, B.M.E., *director, Physical Plant*
 Howard Fretwell, B.B.A., *director, Personnel*
 Charles N. Ramsey, B.B.A., *assistant director, Personnel*
 Robert B. Logan, *division head, Bookstores and Printing*

Office of the Vice-president for Development and Public Relations

Joe W. Guthridge, B.S., *vice-president, Development and Public Relations and executive secretary, Georgia Tech Foundation, Inc.*

John P. Culver, M.A., *director, Public Relations*

I. James Wynn, *director, Information Services*

Edward M. Peabody, A.B., *director, Publications*

W. Roane Beard, B.S., *director, Alumni Affairs*

Robert H. Rice, B.S., *director, Alumni Programs*

Lester M. Anderson, B.S., *director, Annual Giving*

Mary G. Peeks, *director, Alumni Placement*

Michael Donahue, *director, Placement*

Mary Carmichael, *associate director, Placement*

John David Morgan, B.S., *director, Resources Development*

Office of the Vice-president for Planning

Clyde D. Robbins, Ph.D., *vice-president, Planning*

Paul Weber, Ph.D., *special assistant to the vice-president for planning and vice-president for planning emeritus*

David O. Savini, B.Arch., *campus architect*

Paul vanderHorst, B.L.A., *campus landscape architect*

Thomas R. Kirby, B.S., *facilities planner*

College of Engineering

Thomas E. Stelson, D.Sc., *dean*

Walter O. Carlson, Ph.D., *dean, Southern Technical Institute*

Albert P. Sheppard, Jr., Ph.D., *associate dean*

Charles R. Vail, Ph.D., *associate dean*

Hoyt L. McClure, M.S., *associate dean, Southern Technical Institute*

F.W. Schutz, Jr., Ph.D., *assistant to the dean for guidance*

Paul Reynolds, Jr., M.S. *assistant to the dean*

Esther Lee Burks, B.A., *special assistant to dean of engineering for women*

General College

H.S. Valk, Ph.D., *dean*

William H. Eberhardt, Ph.D., *associate dean*

Daniel P. Tomasulo, *assistant to the dean*

Virginia S. Watts, Ph.D., *assistant to the dean*

College of Industrial Management

Ferdinand K. Levy, Ph.D., *dean*

Richard D. Teach, Ph.D., *associate dean*

Gloria M. Shatto, Ph.D., *associate dean*

Engineering Experiment Station

M.W. Long, Ph.D., *director*

Rudolph L. Yobs, M.S., *assistant director, Technical Support*

Gordon R. Harrison, Ph.D., *assistant director, Applied Sciences*

R.C. Johnson, Ph.D., *assistant director, Systems and Techniques*

Cooperative Division

James Gordon Wohlford, M.S., *director*

William H. Hitch, B.M.E., *associate director*

Cary D. Baldwin, B.M.E., *assistant director*

Office of the Registrar

Frank E. Roper, M.S.I.E., *registrar*

William F. Leslie, M.S., *associate registrar and director, Registration and Records*

Mark C. Kelly, B.S.I.M., *assistant director, Registration and Records*

Jerry L. Hitt, M.Ed., *director, Admissions*

James L. Clegg, Th.M., *assistant director, Admissions*

Billy S. Smith, B.B.A., *assistant director, Admissions*

Robert W. James, B.S., *admissions counselor*

Martha Grant, *admissions counselor*

William T. Lee, B.S., *director, Financial Aid*

Dorothy McClure, A.B., *financial aid counselor*

Richard J. Manley, B.C.S., *head, Data Processing*

Frank L. Jenkins, *assistant head, Data Processing*

Office of the Dean of Students

James E. Dull, M.Ed., *dean of students*

Edwin P. Kohler, B.A., *associate dean of students*

Judith E. Priddy, M.Ed., *dean of women*

W. Miller Templeton, M.S., *assistant dean and international student adviser*

Jerry D. Gallups, B.S., *assistant dean and adviser to fraternities*

John A. Wilhelm, M.D., *director, Student Health Service*

James A. Strickland, Ed.D., *director, Student Counseling Center*
Gary J. Schwarzmuller, M.S., *director, Housing*
Roger E. Wehrle, B.S., *director, Fred B. Wenn Student Center*
Donald R. Nelson, B.D., *director, New Student Orientation*

Office of Institutional Research

Rocker T. Staton, Ph.D., *director, Institutional Research*

Office of Computing Services

C.P. Reed, Jr., M.S., *director, Computing Services*
Gary G. Watson, M.S., *associate director, Application System Design*
Jerry W. Head, B.S., *associate director, Application System Programming*
S. Paine Lenoir, M.S., *associate director, Computer Operations*
Frank Gleason, M.S., *assistant to the director*

Applied Computer Research Division

I.E. Perlin, Ph.D., *director, Computer Research Division*

Libraries

E. Graham Roberts, Ph.D., *director, the Libraries*
Arthur T. Kittle, D.L.S., *associate director*

Division of Graduate Studies and Research

Sam C. Webb, Ph.D., *dean, Graduate Studies and Research*
Karl M. Murphy, Ph.D., *assistant dean*

Department of Continuing Education

Richard Wiegand, Ph.D., *director, Continuing Education*
Robert S. Herndon, M.Ed., *associate director*
George H. Adams, B.S., *assistant director*

Office of Research Administration

Milton W. Bennett, M.S., *acting director, Research Administration*

Georgia Tech Research Institute

Robert H. Ferst, B.S., *interim president, Research Institute*
Robley H. Tatum, B.S., *assistant to the president*
Milton W. Bennett, M.S., *general manager*

Office of Interdisciplinary Programs

Melvin W. Carter, Ph.D., *director, Interdisciplinary Programs and
director, Bioengineering Center*
L. Douglas James, Ph.D., *acting director, Environmental
Resources Center*

Health Systems Research Center

Harold E. Smalley, Ph.D., *director, Health Systems Research
Center*
A.D. Joseph Emerzian, Ph.D., *associate director*

Department of Campus Safety

Richard Fuller, Jr., Ph.D., *director*
G.L. Petherick, B.A., *assistant director*
George Gardiner, *acting chief of police*

Georgia Tech Athletic Association

Robert L. Dodd, *athletic director*
John McKenna, B.A., *associate athletic director*

Standing Committees of the Faculty 1974-75

Executive Committee

V. Crawford, *chairman*, M.C. Payne (2), P.H. Sanders (1), F.A.
Tarpley (1), J.E. Dull, F.K. Levy, F.E. Roper, T.E. Stelson, H.S. Valk

Academic Senate

Curriculum

V. Crawford, *chairman*, W.Z. Black (2), J.Q. Williams (2), D.T.
Paris (1), R.W. Carney (1), F.K. Levy, F.E. Roper, T.E. Stelson, H.S.
Valk

Student Academic and Financial Affairs

J.P. Smith (3), J.A. Kelly (2), M. V. Law (2), W.Z. Black (1), J.V. Herod (1), F.E. Roper, three student representatives

Student Activities

J.J. Bynum (3), C.L. Liotta (2), J.T. Sommerfield (2), B.D. Beavers (1), R.F. O'Connor (1) J.E. Dull, three student representatives

Student Grievance and Appeal

S.L. Dickerson (3), T.W. Murray (2), M.J. Marr (1), two student representatives

Student Honor

A.F. Beckum (3), D.C. O'Shea (2), J.L. Hammond (1), N.N. Naugle (1), three student representatives

Student Regulations

J.N. Smith (3), J.G. Wohlford (3), E.G. Roberts (2), C.V. Smith (2), A.D. Smith (1), L.A. Woodward (1), three student representatives

General Faculty

Academic Services

W.H. Eberhardt (3), J.D. Muzzy (3) D.C. Ray (2), J.A. Stanfield (2), R.C. Johnson (1), A.W. Stalnaker (1), one student representative

Faculty Benefits

W.D. Winer (3), E.B. Joy (2), J.A. Wilhelm (2), A.P. Bugg (1), S.W. Thornton (1), E.I. Barnes, one student representative

Faculty Honors

J.B. Hamen (3), D.E. Fyffe (2), G.J. Day (1), T.L. Weatherly (1), one student representative

Faculty Status and Grievance

D.A. Robinson (3), R.A. Young (3), P.G. Mayer (2), E.J. Baker (1), K.L. Su (1)

Public Relations

F.C. Allvine (3), R.J. Corbin (3), R.W. Hammond (2), R. Wiegand (1), J.P. Culver, J.W. Guthridge, one student representative

Statutes

R.E. Green (3), H.A. Corriher (2), E.W. Thomas (2), K.M. Murphy (1), G.P. Rodrigue (1) F.E. Roper, one student representative

Welfare and Security

E.R. Bollinger, Jr. (3), F.W. Stallard (3), R.M. Goodman (2), G.R. Harrison (2), W.L. Bloom (1), H.C. Ward (1), one student representative

Special Committees of the Faculty – 1974-75

Computer Advisory Board

Dr. J.A. Bertrand, *chemistry*

Mr. Charles Bonham, *Engineering Experiment Station*

Ms. Teresa Chan, *library*

Professor L.Z. Emkin, *civil engineering*

Professor D.S. Harmer, *nuclear engineering*

Mr. Frank Huff, *director of financial affairs*

Professor A.P. Jensen, *information and computer science*
(*chairman*)

Mr. Leonard Kinard, *registrar's office*

Professor Richard Teach, *industrial management*

Professor J.L. Keown, *Southern Technical Institute*

Mr. Charles L. Till, *undergraduate student representative*

Mr. David R. James, *graduate student representative*

Mr. Charles Reed, *ex-officio member*

Foreign Students

J.D. Wright, *chairman*, J.L. Clegg, D.B. Comer, III, J.E. Dull, R.R. Spillman, Miller Templeton, J.T.S. Wang, L.T. Zahn

New Student Orientation

Don Nelson, *chairman*, Doris Bowers, Richard Browning, Robert Dean, W.H. Eberhardt, Jerry Gallups, Keith Ivey, William Leslie, Albert Mangin, Robert McMath, Tom McMurrain, Gloria Shatto, Miller Templeton, Charles Vail, George Williams, Jim Wynn

Nuclear Safeguards

G.G. Eichholz, *chairman*, F.C. Apple, Robert M. Boyd, J.D. Clement, Monte V. Davis, W.W. Graham, R.A. Karam, R.S. Kirkland, G.W. Leddicotte

Parking Appeals Board

A.L. Stanford, *chairman*, G.L. Petherick, *secretary*, Sarah Born, John Culver, W.H. Hitch, W.F. McAfee, Paul Sanders

Pre-Medical and Pre-Health Career Advising

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As of April 20, 1974

After each name is listed the highest earned degree and its source. The academic rank is followed by the individual's major assignment. Professional registration is indicated with the state(s) of registration as follows: P.E. = Professional Engineer, L.S. = Land Surveyor, R.A. = Registered Architect, L.A. = Landscape Architect.

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